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THE DRYING OF MARINE SEDIMENTS FOR WATER CONTENT DETERMINATIONS

by

John David King

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THESIS

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FOR WATER CONTENT DETERMINATIONS

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October 1969

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The Drying of Marine Sediments

For Water Content Determinations

by

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Lieutenant, United States Navy
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Submitted in partial fulfillment of the
requirements for the degree of

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ABSTRACT

The question pertaining to the acceptance of a standard drying temperature of 110 $\pm$ 5°C in making water content determinations of soils has been extended to the oven drying of marine sediments. The implementation of a temperature within the 130 to 150°C range appears to be just as adequate as the accepted standard for the drying of inorganic sediments and has the added advantage of shortening the drying time. Increasing the temperature above 150°C does not appreciably reduce the drying time and may begin to break down the less stable clay sediments such as montmorillonite. The water content determinations appear to fluctuate in a random manner with increase in drying temperature suggesting that the mineralogy of the sediments somehow controls water content. The concept of normalized water content is introduced and appears to be an invaluable aid in considering the relationships between water content, sample weight and drying time.

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ACKNOWLEDGMENTS

A sincere debt of gratitude is owed to Dr. R. J. Smith of the Department of Oceanography for suggesting this study. Without Dr. Smith's generous allotment of time, talent, and critical comments, successful completion of this study would not have been possible. Additionally, Mr. M. Hironaka and Mr. L. Nunes of the Naval Civil Engineering Laboratory at Port Hueneme, California, and The Inter Laboratory Committee on Facilities rendered valuable services in conducting the grain size analyses and carbon determinations. This work has been partially supported by the Naval Facilities Engineering Command.

I. INTRODUCTION

A. GENERAL

The testing procedures for the drying of terrestrial soils have been in existence for some time. However, it wasn't until 1963 that the final form of these procedures was adopted by the American Society for Testing and Materials (1964). Lack of standardized procedures in marine sedimentology has resulted in the adoption of the procedures commonly used in the water content studies for soils. Accordingly, the purpose of this study is to explore the universally accepted drying temperature of 110 $\pm$ 5^{o}C (230 $\pm$ 9^{o}F) in hopes of answering the question, "What is the best temperature to use in the drying of marine sediments?" In addition, an investigation of the variability of water content with parameters such as drying temperature and sample weight is considered.

B. SCOPE OF STUDY

The subsequent study of drying temperature was limited to the temperature range of from 90 to 170^{o}C. In all, six sediments were tested over this temperature range. Grain size analyses and organic carbon determinations were conducted mainly to classify the sediments according to the Wentworth Scale. X-ray diffraction was utilized to better define the composition of the finer constituents.

C. SUMMARY OF PREVIOUS WORK

As mentioned previously, ASTM contains the now well accepted procedures for testing soils. Briefly it is indicated that soils obtained from the field will be oven dried at either 60°C (140°F) or 110 ± 5°C (230 ± 9°F) for a period of 12 hours or until a constant weight between successive weighings is achieved. That is, if one is concerned with the drying of organic soils (soils containing more than about 4% organic carbon by weight), the lower temperature of 60°C should be used. Otherwise a drying temperature of 110 ± 5°C is to be employed. These standards apply to the drying of soils for most of the standard engineering tests normally conducted. The more common tests normally conducted include grain size analysis, moisture or water content determination, and specific gravity measurement.

Especially of notable interest is the work of Lambe (1951). Again a controlled constant temperature of 110°C is suggested. However, the author is quick to note that there is nothing binding about 110°C which makes its selection as a drying temperature scientific. Lambe (1949) showed this in an earlier work where he plotted water content against drying temperature for five soils of extremely different structural characteristics. In all cases the water content was found to increase steadily with increase in drying temperature. The highly plastic soils such as Mexico City Clay and diatomaceous earth showed a rapid increase in water content with the increase in drying temperatures for temperatures greater than 140°C. In contrast the Ottawa sand and the comparatively non-plastic Boston blue clay showed little increase in water content with increasing drying temperature over the entire temperature range of 60 to 200°C. Lambe further asks, "Just how 'dry' is a dry soil?" Most engineering specifications define dry weight of a soil as that weight obtained by heating the soil at 110°C until the weight reaches a constant value. The absorbed layer of water (hygroscopic water) surrounding finer grained soil constituents can be driven off only at temperatures much greater than 110°C. The majority of the water absorbed by a soil is, however, interstitial and may be successfully driven off by heating at a temperature of 110°C.

Unfortunately no published definitive procedures exist for the oven drying of marine sediments. Apparently the studies to date have been conducted utilizing the accepted drying temperature procedures for terrestrial soils. For example, Richards and Keller (1962) studied the variance of water content with depth of a long core taken off the coast of Nova Scotia employing the standard controlled drying temperature of 110°C. Since questions have been raised by at least one investigator concerning the best drying temperature for terrestrial soils, the present acceptance of the 110°C standard must also be questioned for the drying of marine sediments.

II. PROCEDURE

A. COLLECTION AND STOWAGE OF SAMPLES

A total of six samples were collected from four differing marine environments. The first two samples studied were inherited from a former student of the Naval Postgraduate School, Lieutenant R. A. Erchul. Lieutenant Erchul collected these samples in a lagoon at Seal Beach near Long Beach in southern California. The location of these samples as well as the location of the four remaining samples discussed below are given in Figures 1 through 3. The area of the lagoon sampled remains continuously submerged although the lagoon itself is subjected to tidal movements. These samples were stowed at room temperature in five gallon plastic containers in order to avoid the introduction of foreign material from oxidation of the container. For identification purposes these two samples were designated Seal Beach No. 1 and Seal Beach No. 2.

Two of the remaining samples studied were obtained by the author in the upper end of Elkhorn Slough, near Moss Landing in central California. The area sampled is typical of many estuarine environments. It has a fresh water source, Elkhorn Creek, flowing into the estuary from the east. Typically, the water level of the slough is controlled exclusively by the influence of the tides. Elkhorn Creek contributes little fresh water to the slough much of

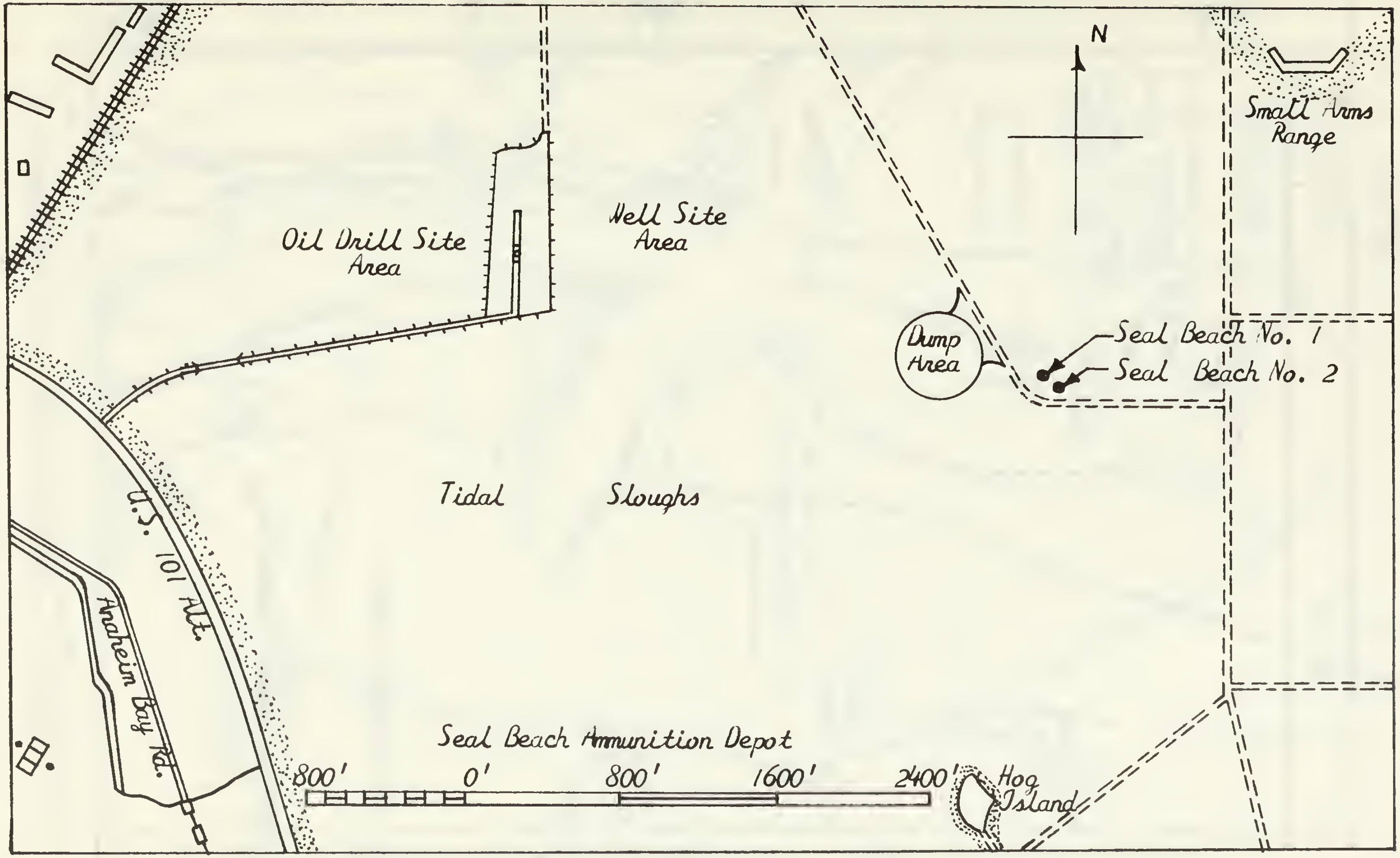

Figure 1. Location of Seal Beach Samples

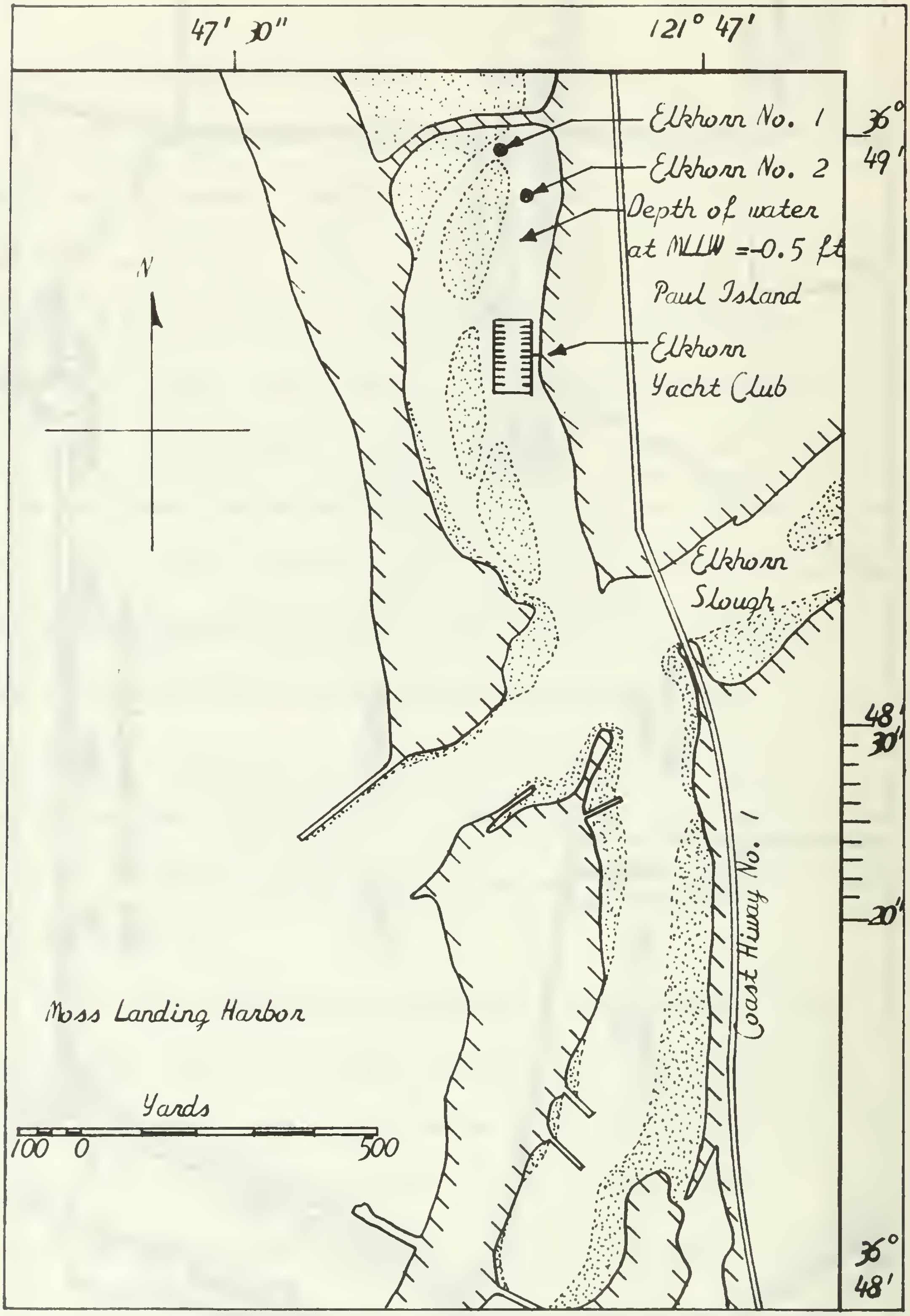

Figure 2. Location of Elkhorn Slough Samples

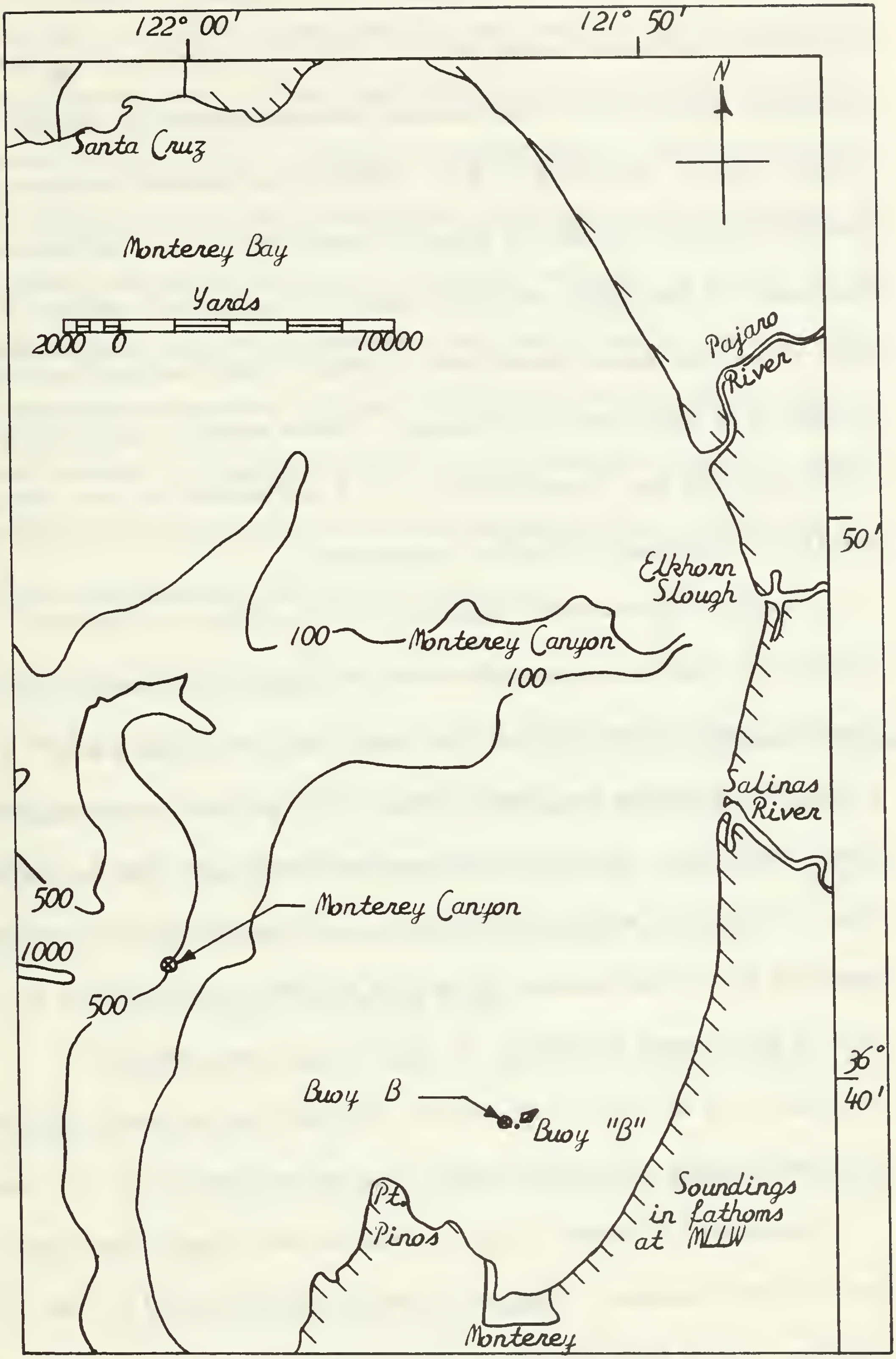

Figure 3. Location of Monterey Canyon and Buoy B Samples

the year with the notable exception of the release of runoff from adjacent farm lands during periods of heavy winter rains. The sampling area remains continuously submerged except during minus tides of less than -1.5 ft. These brief exposed periods occur only during spring tides or about 12 times per year. Salinity of the water in the upper end of the slough is essentially the same as that of the sea water immediately seaward thus insuring that this sediment is truly marine in nature. These samples were designated Elkhorn No. 1 and Elkhorn No. 2 and stowed at room temperature in one gallon plastic containers.

The fifth sample was obtained from the floor of Monterey submarine canyon in approximately 1060 meters of water. An Onorati gravity corer with a four inch diameter sampling tube was employed, utilizing the Naval Postgraduate School's oceanographic research vessel. A short core, approximately one foot in depth, was obtained and similarly placed in a one gallon plastic container, insuring that about one inch of in situ sea water covered the surface of the stowed sediment. A short core was necessary to eliminate, or at least to minimize, the variation of water content with core length since this aspect was not considered in this study.

An area of Monterey Bay near the seaward end of the outer boat channel leading to Monterey Harbor was selected for the sixth sample. Again the School's oceanographic research vessel was utilized, only this time a Smith-MacEntyre grab-type bottom sampler was used to obtain the desired sample. This particular sampler was used in that it sacrifices vertical sample depth in lieu of lateral extent. That is, a hemispherical shaped sample having a surface area approximating 12 x 12 inches and having a maximum depth of 8 inches is obtained. Using this device, a suitable sample was obtained from a depth of 68 meters at a position immediately seaward of Buoy B (Figure 3). This sample again was stowed in a manner similar to the previous samples. Since biological activity was not of interest, stowing the samples at room temperature proved to be sufficient.

B. EQUIPMENT USED

The equipment used in the oven drying of the sediment samples consisted of a forced-air circulation oven, an analytical beam balance, and aluminum alloy drying tins. The characteristics and limitations of the basic components are listed as follows.

1. Forced-air Circulation Oven

Manufacturer and Model Number: Central Scientific Company, Model No. 95379.

Dimensions (inside): width, 16 inches; depth, 15 inches; height, 19 inches.

Temperature Range: 60 - 260°C

Control Sensitivity: $\pm$ 0.5°C

Temperature Uniformity: at 100°C, $\pm$ 1.0°C;
at 175°C, $\pm$ 1.5°C.

The oven is of double-wall construction with inner and outer walls separated by three inches of glass-wool insulation. A variable thermostat was used to control the inside air temperature. An inversion type thermometer was used to indicate the temperature at a particular drying level within the oven.

2. Analytical Balance

Manufacturer and Model Number: Mettler Instrument Corporation, Model No. H6T Digital

Range: 0 - 160 g

Precision (standard deviation): $\pm$ 0.05 mg

Reliability: 0.1 mg

The balance is the beam type with symmetrical air damping and has a chrome-nickel-steel weighing pan.

3. Drying Tins

Size and description: The drying tins used were of 0.04 inch aluminum alloy construction measuring 1.95 inches inside diameter and 0.90 inches in height (without lid).

C. DRYING PROCEDURES

The aforementioned six samples were sub-sampled and oven dried at 10^{o}C increments over a range from 90 to 170^{o}C. Four sub-samples of randomly varying weight between 20 and 50 grams were taken of each sediment for each of the ten degree temperature increments. Detailed procedures of the drying process follow. The drying tins were initially weighed on the analytical balance and their respective weights recorded on the Water Content Data Sheets, (Figure 4). In each tin was placed a random amount of sediment taken from the plastic stowage container. The tins were again weighed with the results recorded on the appropriate data sheet. During this time the oven was energized and had settled out at the predetermined drying temperature. When the oven had reached the desired temperature, plus approximately 4°C to compensate for a temperature drop due to the insertion of the samples, the tins were placed in the oven on the same level as the sensing tip of the inversion thermometer.

All experiments subsequently conducted included the placing of the sub-samples at the same predetermined level within the oven. This procedure was adopted to eliminate a possible temperature variability within the oven chamber. Additionally, the sensitivity and temperature uniformity within the oven with the thermometer set at different heights, was checked through the use of a highly sensitive potentiometer. A depth of 9.5 inches from the inside top of the oven was adopted for all tests conducted. This height was chosen because the results obtained using the independent temperature measuring device agreed most favorably with the manufacturer's specifications.

The first two hours of the drying period proved the most critical as to temperature fluctuation and regulation. As mentioned previously, the setting of the oven at a temperature about 4°C above the desired drying temperature to compensate for the introduction of eight sub-samples appeared satisfactory. For example, if a drying temperature of 100°C was desired, the oven was preheated to a temperature of 104°C. Since most of the interstitial water is driven off in the first two hours, it was necessary to periodically check and correct the drying temperature by using the external thermostatic control on the oven. Checking the temperature every fifteen minutes and correcting for temperature fluctuation as necessary generally proved to be sufficient. The higher drying temperatures (150 to 170°C) necessitated ten minute checks, however, since most of the interstitial water is driven off in the first hour for this temperature range. The drying temperature was found to fluctuate very little after the first two hour period.

Lacking a definitive procedure concerning the periodic weighing of the hot sediment samples, a minimum period between successive weighings of one hour was adopted. Half-hour increments were attempted but it was found that the oven maintained a steady temperature for only about 20 minutes of the 30 minute interval. For lower drying temperatures, a two hour increment was found to be sufficient. Wherever possible, however, the one hour period was adhered to as this shorter time increment made it considerably easier to comprehend the relationship between water content and elapsed time.

An important aspect that had to be considered was the actual weighing of the hot samples. Obviously the covering of the hot tins with the tin lids and the subsequent placing of the samples in a desiccator to be cooled to room temperature before weighing was not consistent with this study. Had this procedure been used, the samples would have been subjected to a complete reheating after each weighing, which would have added appreciably to the time required to dry each sample. Opposed to this well-founded weighing procedure is the controversial hot weighing of samples. The disadvantage of unsymmetrical heating of the pan of the analytic balance, introduced by the hot sample technique, is well recognized (Lambe, 1951). During this study it was found that placing the first hot sample on the pan introduced an error of + 0.015 g, the error having been ascertained by removing the hot sample from the weighing pan and rebalancing the scale. This error was found to remain constant over the remaining sub-sample weighings. With this constant error established, results obtained using the hot sample technique were found to be compatible with those obtained using the standard desiccator or cool sample technique.

Establishment of an end point to the weighing process requires defining the dry weight of a sediment sample. As mentioned earlier, sample dry weight is generally defined as the weight achieved when two successive weighings yield the same result. For purposes of moisture content study, the American Society for Testing and

Materials (1964) stipulates that a balance sensitive to 0.01g is to be used. Thus a constant weight is achieved when two successive readings are identical to 0.01g. A balance sensitive to 0.00005g was used in the course of this study with the resultant weighings rounded to 0.001g. Although the established procedures requires an accuracy only to a hundredth, a sample was considered to be dry when successive weighings differed by no more than 0.003g. If a scale sensitive only to 0.01g were used, a difference of 0.003g would not be apparent. Thus the definition of dry weight remains as described by the classical literature, although a slightly higher degree of accuracy was employed in these studies.

After finding the dry weight of all eight sub-samples, the sample containers were washed in tap water, carefully dried, and reweighed. The reweighing of the tins after each washing was deemed necessary to eliminate the effect of corrosion and subsequent weight loss of the tins. Although the average weight loss per test was insignificant, i.e., - 0.0003g, its cumulative effect is significant. That is, the tin may loose as much as 0.010g after some thirty uses.

D. X-RAY DIFFRACTION

In the past, use of the X-ray diffractometer has proven to be valuable for identification of the constituents of finer grained marine sediments. In this study it was deemed important to determine if these fine grained sediments were clay-sized clastic mineral components or of true clay mineral composition.

1. Equipment Used

a. X-ray Diffractometer, Data Controler and Processor:

X-ray Tube: Copper target; maximum voltage, 50 KV; maximum amperage, 40 ma; $K\alpha$, 1.54178 A; $K\beta$, 1.39217 Å.

Goniometer Scanning Unit: Nickel filter.

Manufacturer: North American Phillips Company (Norelco); Model No. 10243.

b. Calibration:

Silicon Powder Standard

2. Procedure

Slides of the six sediments were prepared and analyzed using the Naval Postgraduate School's X-ray diffraction equipment. Initially a slide containing the manufacturer's silicon powder standard was run to check the alignment of the scanning unit. Each of the specially prepared blank aluminum holders was then loaded with untreated wet sample and singularly inserted in the scanning unit holder. A scanning rate of two degrees per minute over a range of from four to sixty degrees was used throughout the analysis.

E. GRAIN SIZE ANALYSIS AND ORGANIC CARBON DETERMINATION

Grain size analyses and organic carbon determinations were conducted on each of the six sediments by the Naval Civil Engineering Laboratory (NCEL) at Port Hueneme, California. The grain size distribution permits a classification of the sediment in terms of the sand-silt-clay ratio. The organic carbon test, which in actuality is a by-product of the carbonate carbon test, gives the amount of organic matter present expressed as a percentage of the sample dry weight.

The equipment and procedures used in the grain size analyses follow the specifications delineated by the ASTM (1964). A standard set of square mesh sieves was used to classify the sand fraction. The finer silt-clay fraction, collected on the bottom pan of the sieve set, was subjected to the hydrometer test. This procedure utilized a standardized Baumé hydrometer which was read at designated time intervals. The data obtained was then introduced into the computer program developed by M. Hironaka (1968). The output automatically plotted grain size distribution curves (Figures 25 through 30).

The organic carbon content is obtained together with the carbonate carbon analysis. The carbon fraction of a sediment sample is composed of the carbonate carbon fraction and the organic carbon fraction. A sample containing the total carbon fraction and the necessary reagents and catalysts is first introduced into the LECO carbon determination appraratus, oxidized by heating in a stream of oxygen, and the total carbon content obtained by measurement of the gas volume produced. A second cut of the same raw sample is then mildly heated in dilute hydrochloric acid in order to remove the carbonate content. This second sample is then rerun and the non-carbonate carbon content is obtained. The three volumes therefore available are the total carbon, the organic carbon, and the carbonate carbon volumes.

III. RESULTS

A. DATA COMPUTATION

After several revisions the final form of the data sheet was adopted as shown in Figure 4. The title block of this sheet lists pertinent information pertaining to the identification of the sediment, drying temperature used, sample number of the sediment and the date and starting time of the drying test. The second line lists the dish numbers used. Where two sediments were dried simultaneously the first four dish numbers (dishes 1 through 4) were used exclusively for the first sediment listed in the title block. Dishes 5 through 8 were used for the second sediment. The weight of the tin and the wet sediment appear on the next line. This line further serves as the title head for the eight columns W. C. /N. W. Here N. W. stands for normalized water content while W. C. is the water content given by equation (1). Significant line headings were given numerical prefixes for ease of following through with the water content computations, i. e., Wt. of Dish + Wet Sed. is prefixed by the numerical designator ① . The column headings for the weighing number and the time of the weighing appear immediately beneath line ① . Line ② gives the weight of the tin (dish) and the dry sediment. The weight of the empty tin as measured at the beginning of the test appears on line ③ . The weight of water, line ④ , is the difference between the weight of the

Project: Water Content Study **Sediment:** **Date:**

Drying Temperature: **Sample No.:** **Time:**

Dish Number		1		2		3		4		5		6		7		8	
①Wt. Dish+Wet Sed. →			W.C.														
Weigh. No.	Time (Hrs)		N.W.														
②Wt. Dish+Dry Sed.																	
③Wt. of Dish																	
④Wt. of Water, ①−②																	
⑤Wt. of Dry Sed, ②−③																	
⑥Water Content, ④/⑤																	

Figure 4. Sample Data Sheet

tin plus the wet sediment and the weight of the tin plus the dry sediment. The weight of the dry sediment line ⑤ , is given by the difference between the quantities in lines ② and ③ . The final water content is shown on line ⑥ , the last line on the sheet.

B. WATER CONTENT DEFINED

Classically, two well-known but differing concepts exist for the reporting of moisture content or water content, the terms being synonymous. The more commonly used of the definitions is that of the soil scientist. Basically then, water content is given by the ratio of the weight of water driven off from a given sample divided by the weight of the remaining dry soil (sediment). This ratio is then multiplied by 100, since this parameter normally appears as a percentage. Mathematically this relationship is given by:

$$W.C. = \frac{\text{Weight of water}}{\text{Dry weight of soil}} = \frac{W_S - W_D}{W_D - W_C} \times 100\% \qquad (1)$$

where:

$W.C.$ = water content, in percentage

W_S = weight of container and moist sediment, in grams

W_D = weight of container and dry sediment, in grams

W_C = weight of container, in grams

The geologist's concept of water content is given by a similar relationship wherein the denominator of the ratio is the weight of the wet sediment, or mathematically:

$$W.C. = \frac{\text{Weight of water}}{\text{Wet weight of soil}} = \frac{W_S - W_D}{W_S - W_C} \times 100\% \qquad (2)$$

where the quantities are the same as those given for equation (1). The soil scientist thus allows for water contents in excess of 100% while the geologist's concept restricts the maximum value for water content to 100%. For some applications the first of these two relationships is easier to use in that the denominator of dry weight of soil is a constant value, whereas the wet weight of soil is a non-fixed sum.

C. NORMALIZED WATER CONTENT

It is often advantageous to normalize data in order to minimize the effect of the uncontrolled variability of some of the inputs. A similar problem exists with the analysis of water content studies. That is, a way to minimize the variance of sediment composition and void structure must be devised if meaningful interpretations are to be obtained. The parameter of normalized water content has therefore been introduced and defined as the ratio of the water content at any given time divided by the final water content. The definition of water content as used by the soil scientist and as indicated by the American Society of Testing and Materials, equation (1), has been used exclusively in this study. Mathematically, normalized water content is expressed by the relationship:

$$N.W. = \frac{W.C._{(t)}}{W.C.} \qquad (3)$$

where

N. W. = normalized water content (dimensionless)

$W.C._{(t)}$ = water content at a given time, in percentage

W. C. = final water content, in percentage

The advantage of this concept is shown in the following discussion of the relationship between normalized water content and drying time.

D. DATA REDUCTION

1. Water Content versus Drying Time

Four different methods of organizing the data were considered. In that a primary consideration of this effort was the study of the 90 - 170°C temperature range in the hopes of reducing drying time, the first relationship dealt with was that of the water content versus drying time. A typical representation of this relationship is shown by Figure 5. From this data as presented it is difficult to determine a drying time to correspond with a drying temperature. For purposes of this consideration and the relationships that follow, the data is grouped conveniently into two distinct groups according to weight: 28 $\pm$ 2g and 38 $\pm$ 2g. Hourly entries, therefore, appear in the N. W. /W. C. column of the data sheets of the appendix only where the data corresponds to the above grouping scheme. Although sample weight remains within a well-defined range, 38 $\pm$ 2 g in the case shown in Figure 5, the three variables of water content,

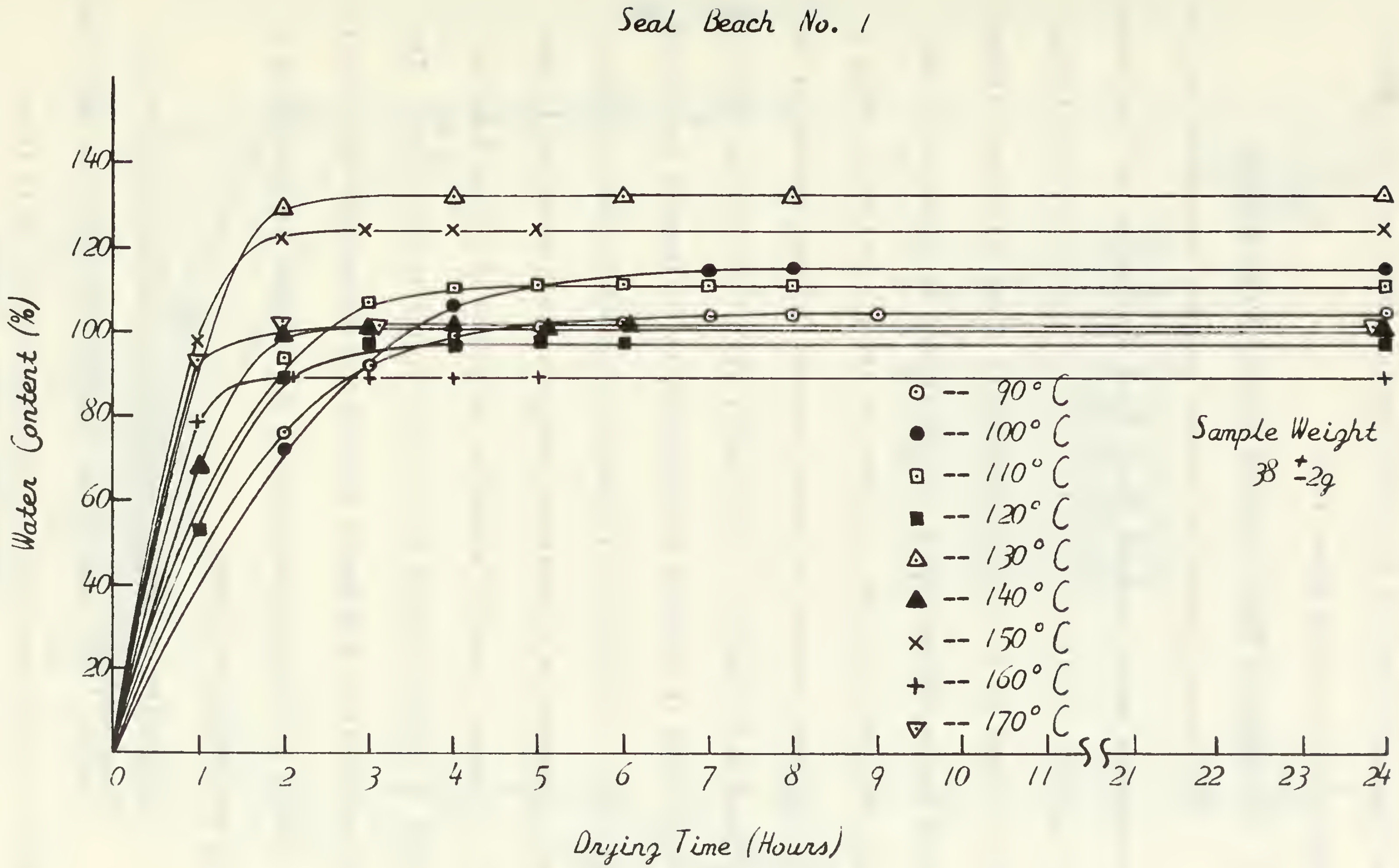

Figure 5. Water Content vs Drying Time for Seal Beach No. 1

drying time, and drying temperature still exist. One of these variables must therefore be normalized in order to obtain a relationship in terms of the other two.

2. Normalized Water Content Versus Drying Time

The normalized water content concept introduced earlier represents the water content at any time divided by the final total water content. Plots of normalized water content versus drying time are shown by Figures 6 through 11. Two variables, drying time and drying temperature, are therefore represented at the expense of restricting the variables of sample weight by using a weight grouping scheme and water content through the use of the normalization technique. It is readily seen from such a plot that the drying time is reduced considerably by increasing the drying temperature. A similar correlation is drawn for each group of four sub-samples at each drying temperature considered in this study. Figures 12 and 13 show the reduction in drying time with decrease in sample weight for a given drying temperature. The drying temperature and water content are therefore restricted in order that a relationship expressing drying time as a function of sample weight can be shown.

3. Comparison of Water Content and Drying Temperature

Lambe (1949) applied the relationships between water content and drying temperature to demonstrate that there is no

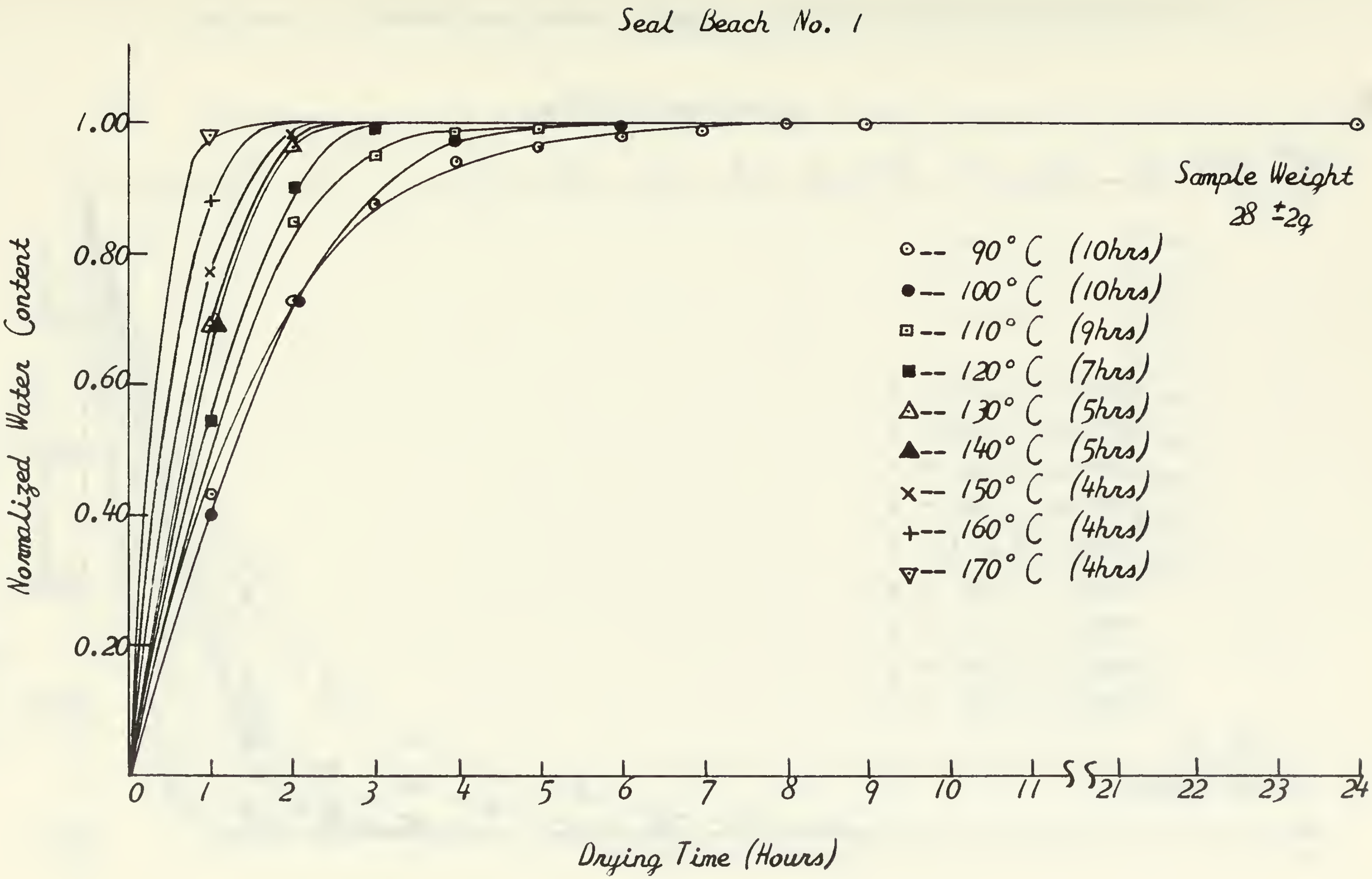

Figure 6. Normalized Water Content vs Drying Time for Seal Beach No. 1

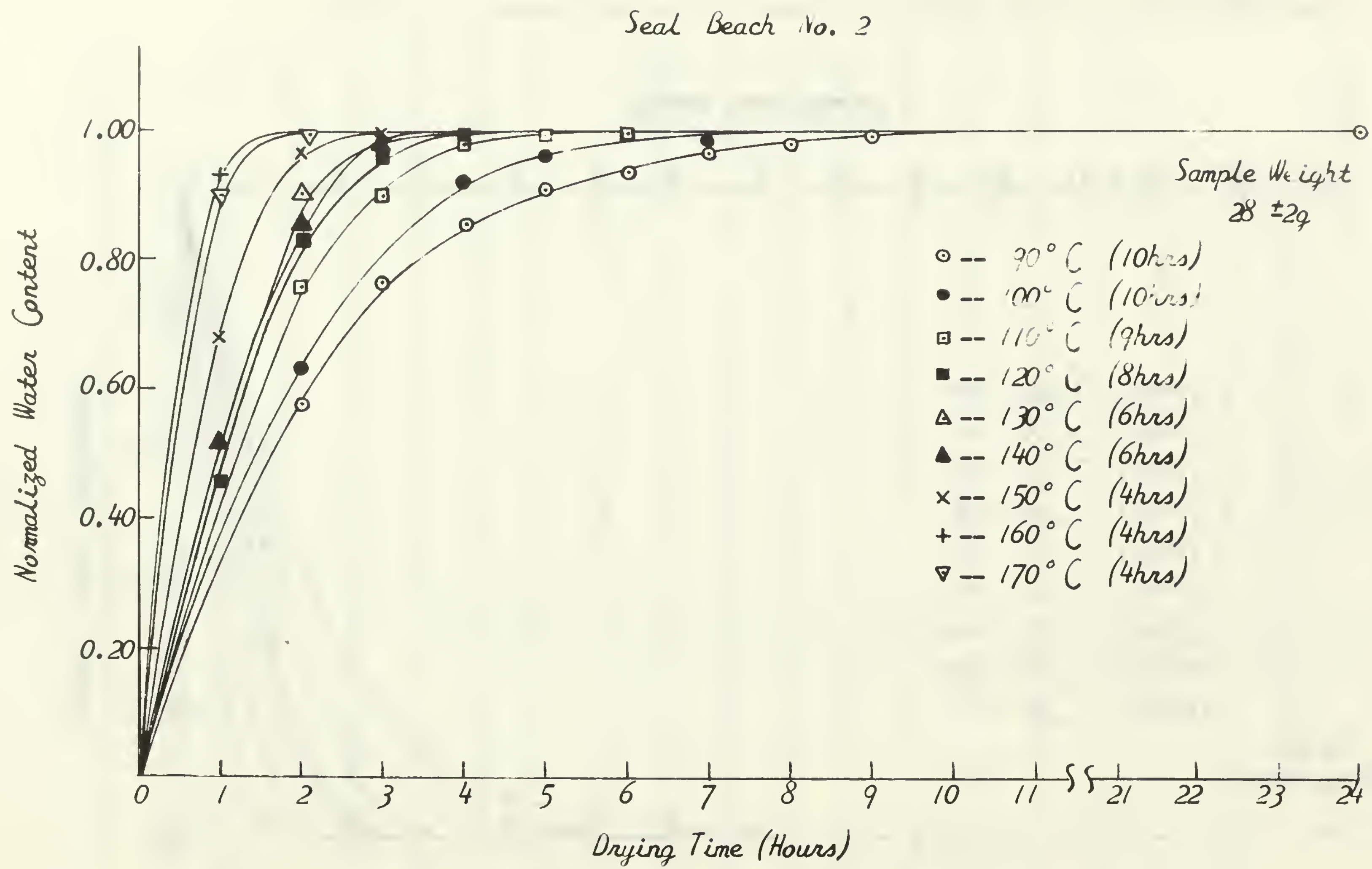

Figure 7. Normalized Water Content vs Drying Time for Seal Beach No. 2

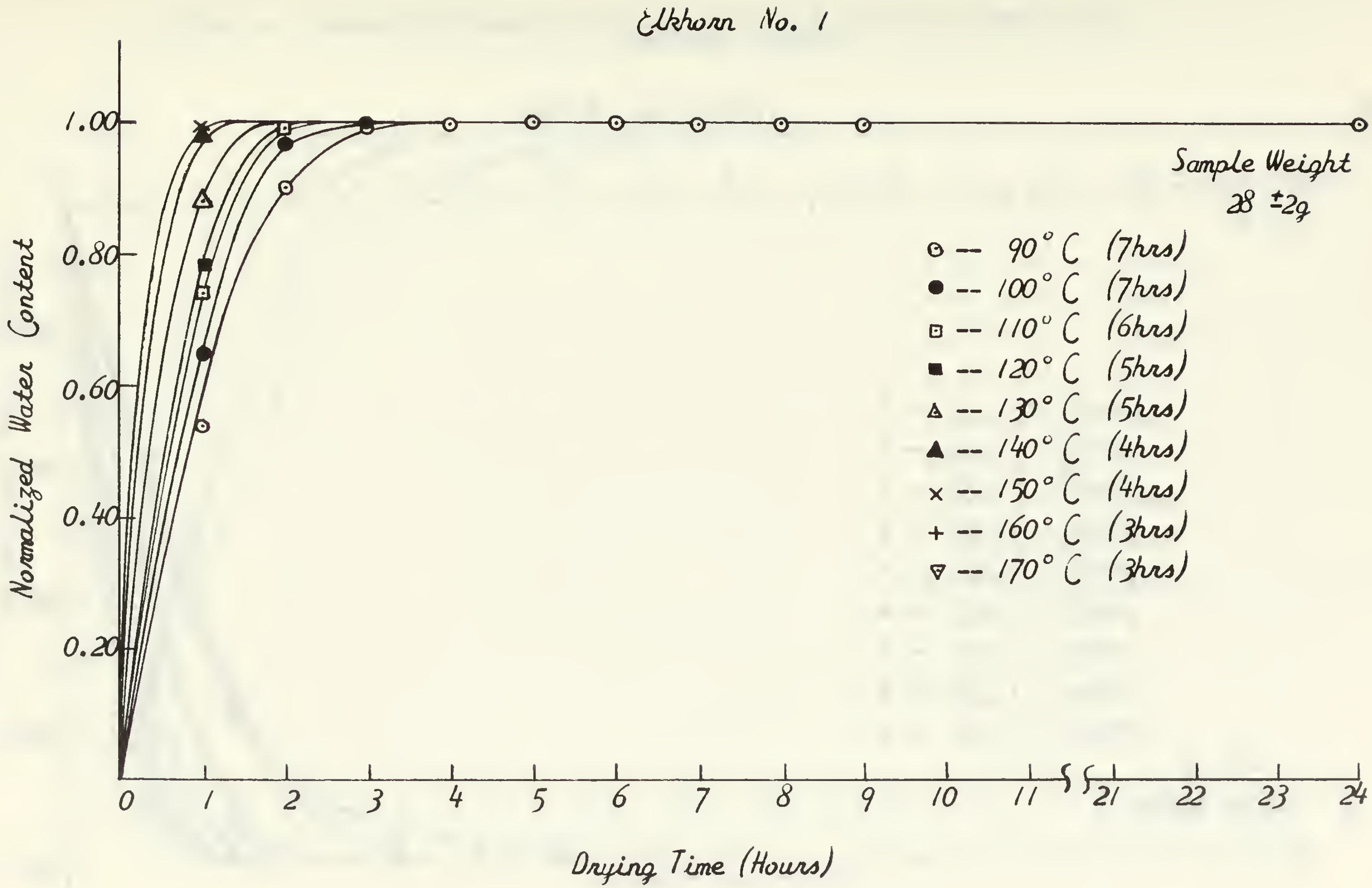

Figure 8. Normalized Water Content vs Drying Time for Elkhorn No. 1

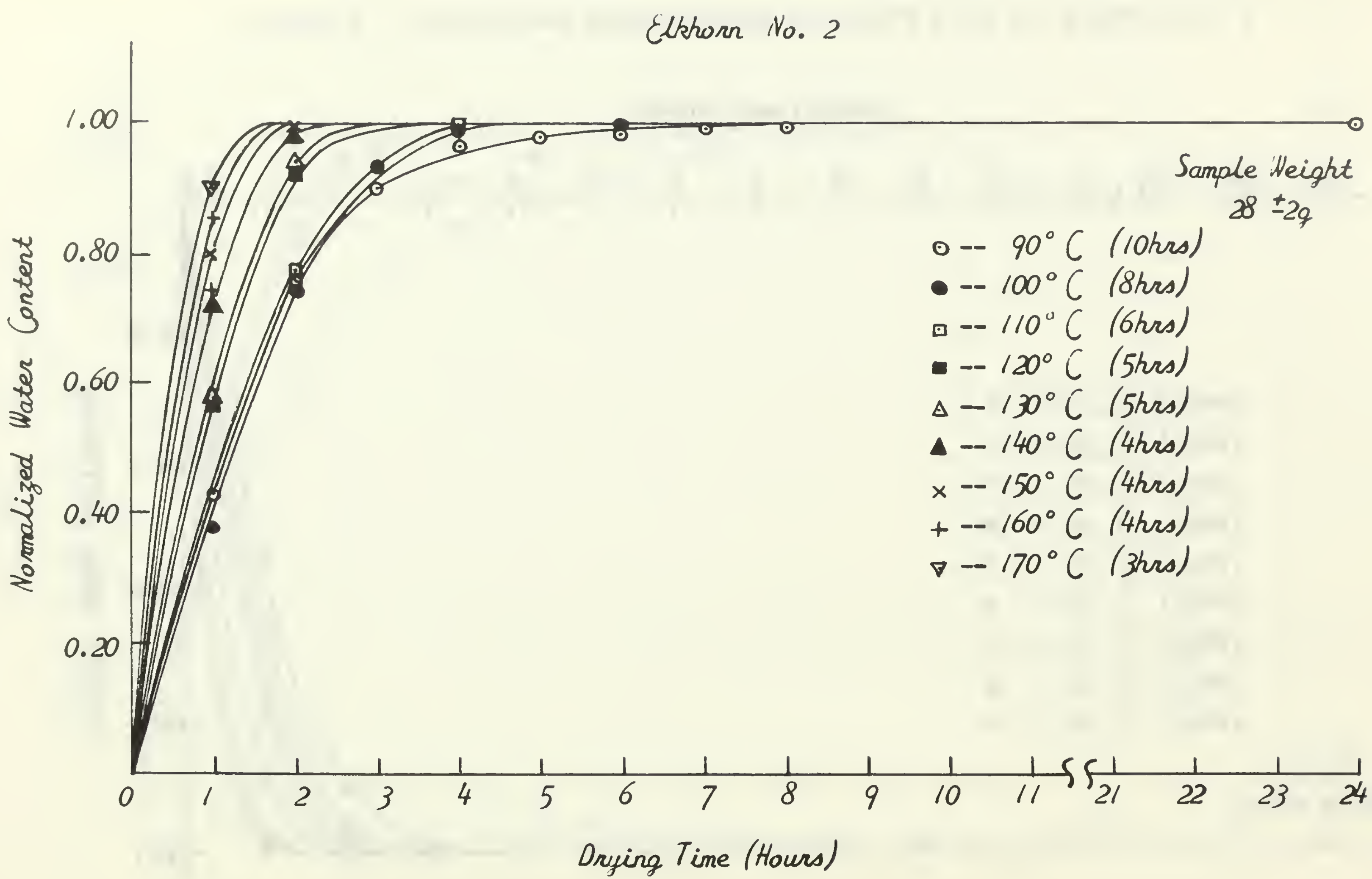

Figure 9. Normalized Water Content vs Drying Time for Elkhorn No. 2

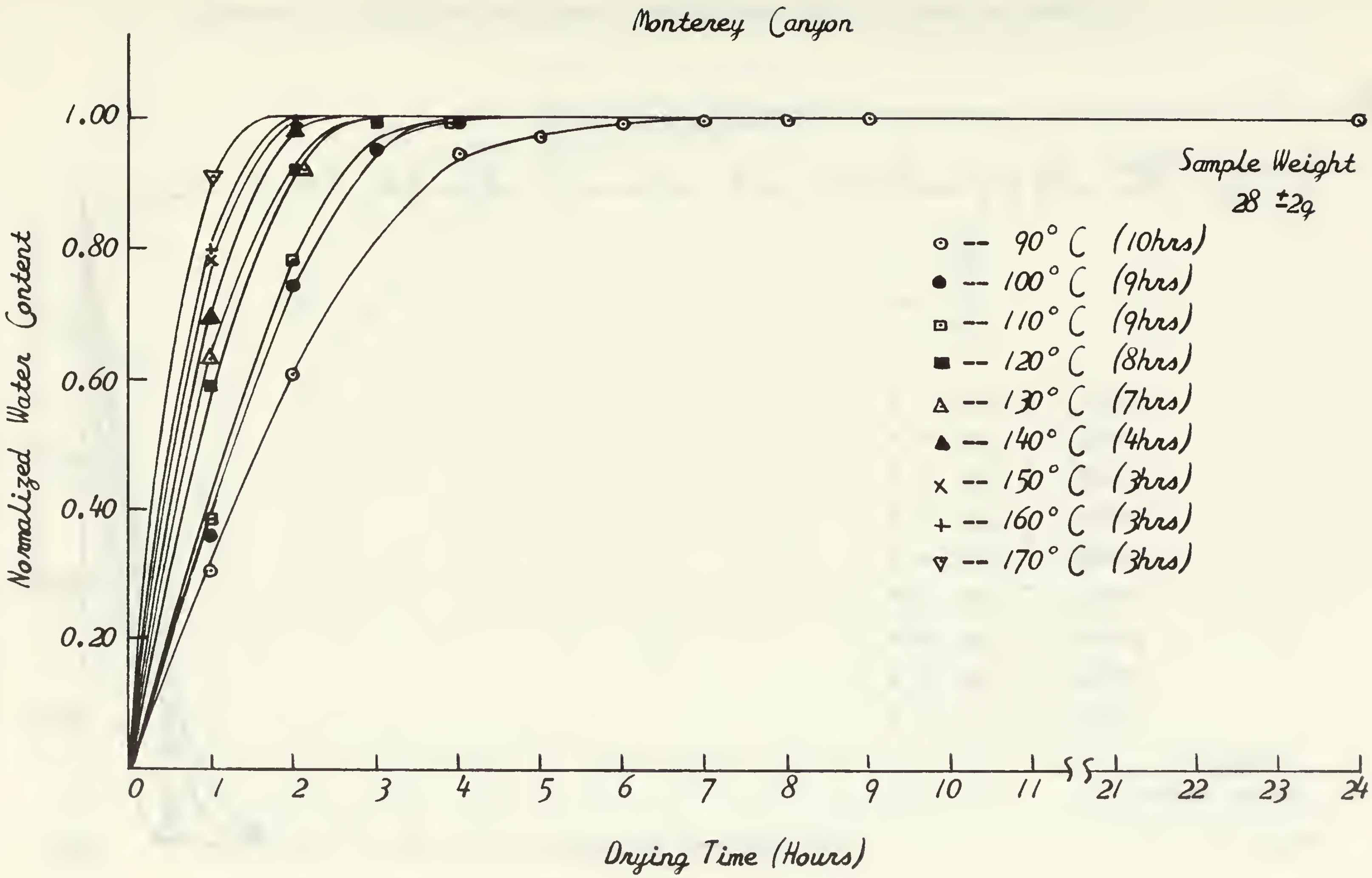

Figure 10. Normalized Water Content vs Drying Time for Monterey Canyon

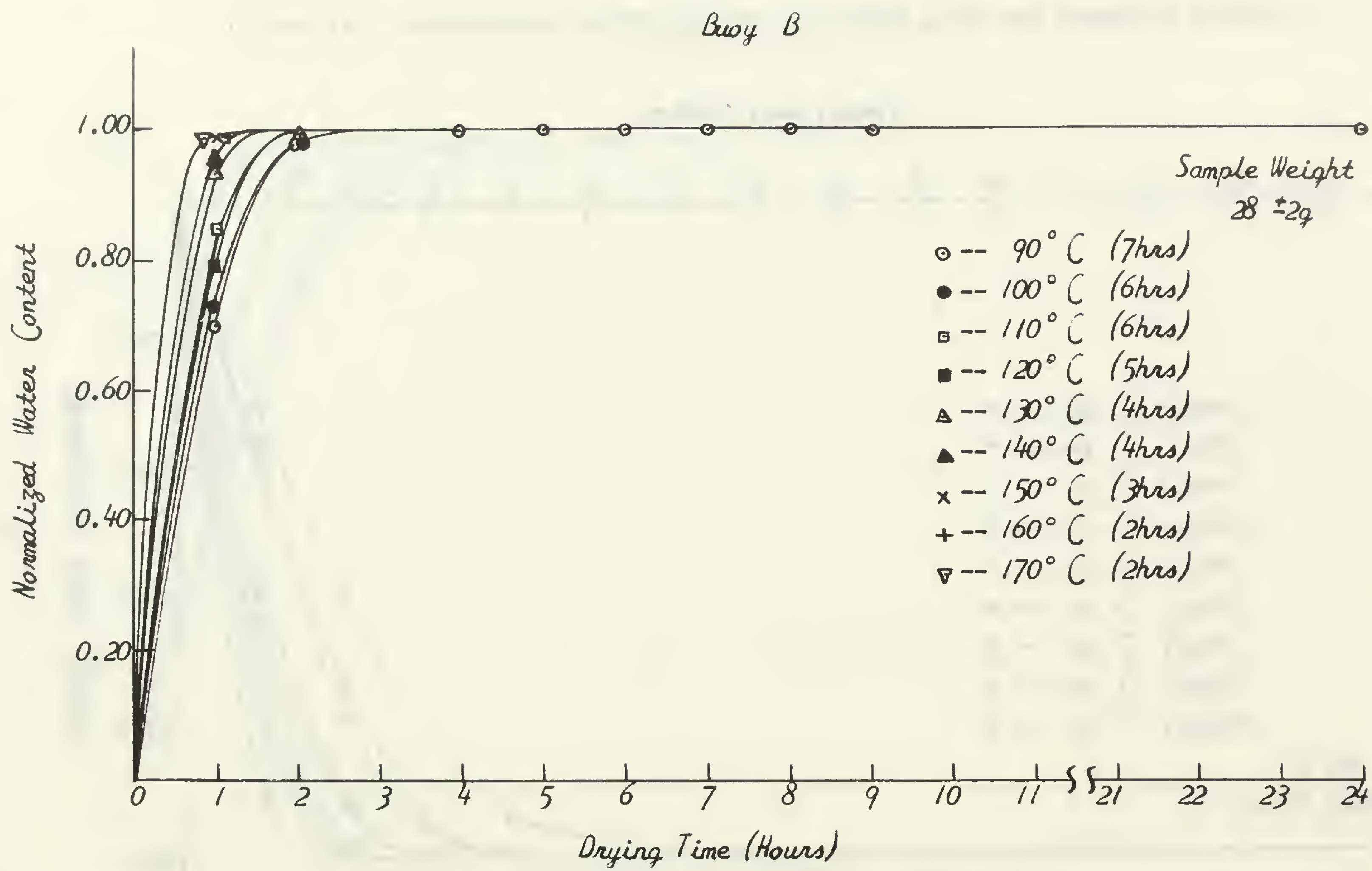

Figure 11. Normalized Water Content vs Drying Time for Buoy B

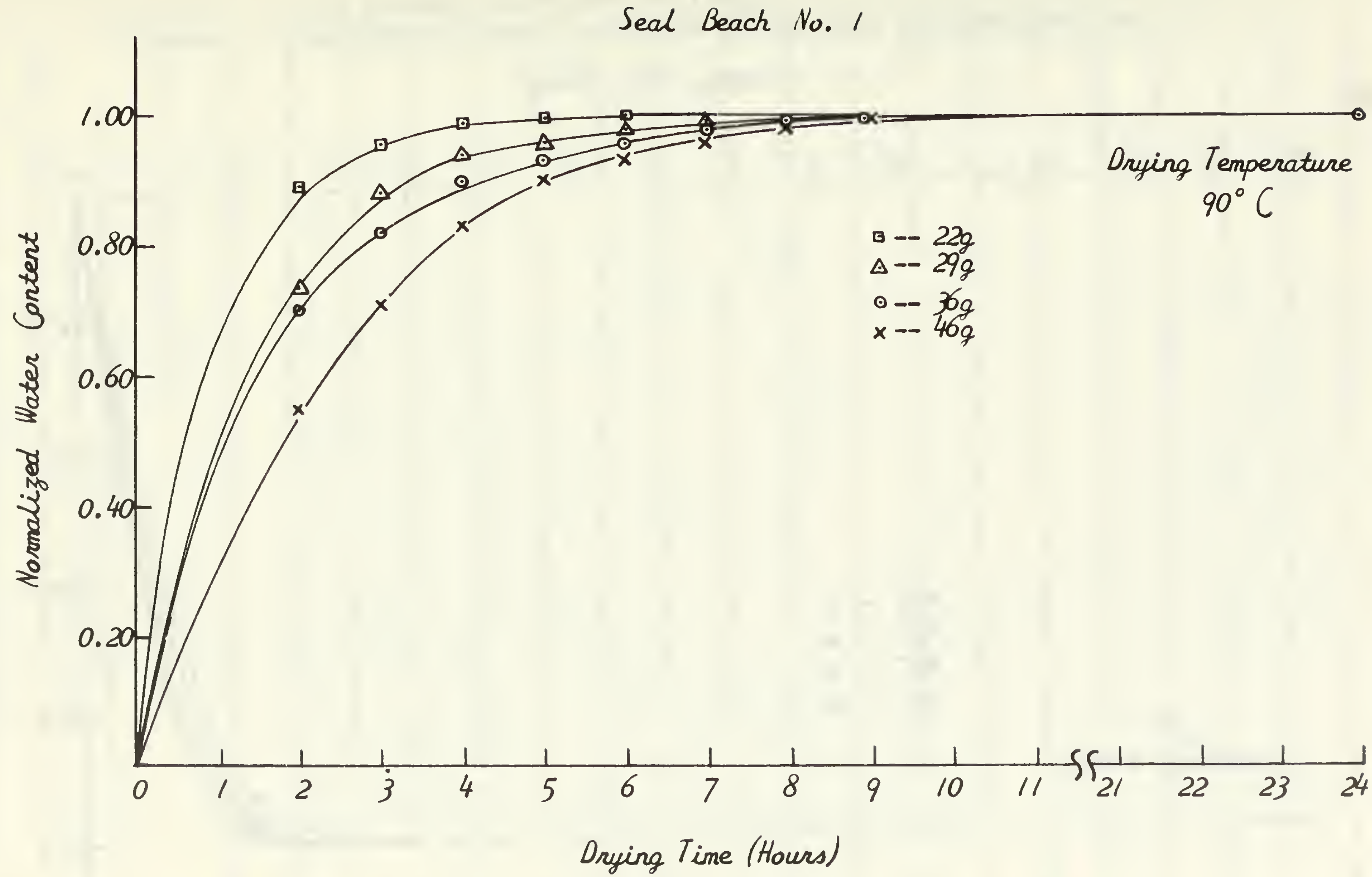

Figure 12. Normalized Water Content vs Drying Time for Seal Beach No. 1 at a Drying Temperature of 90°C

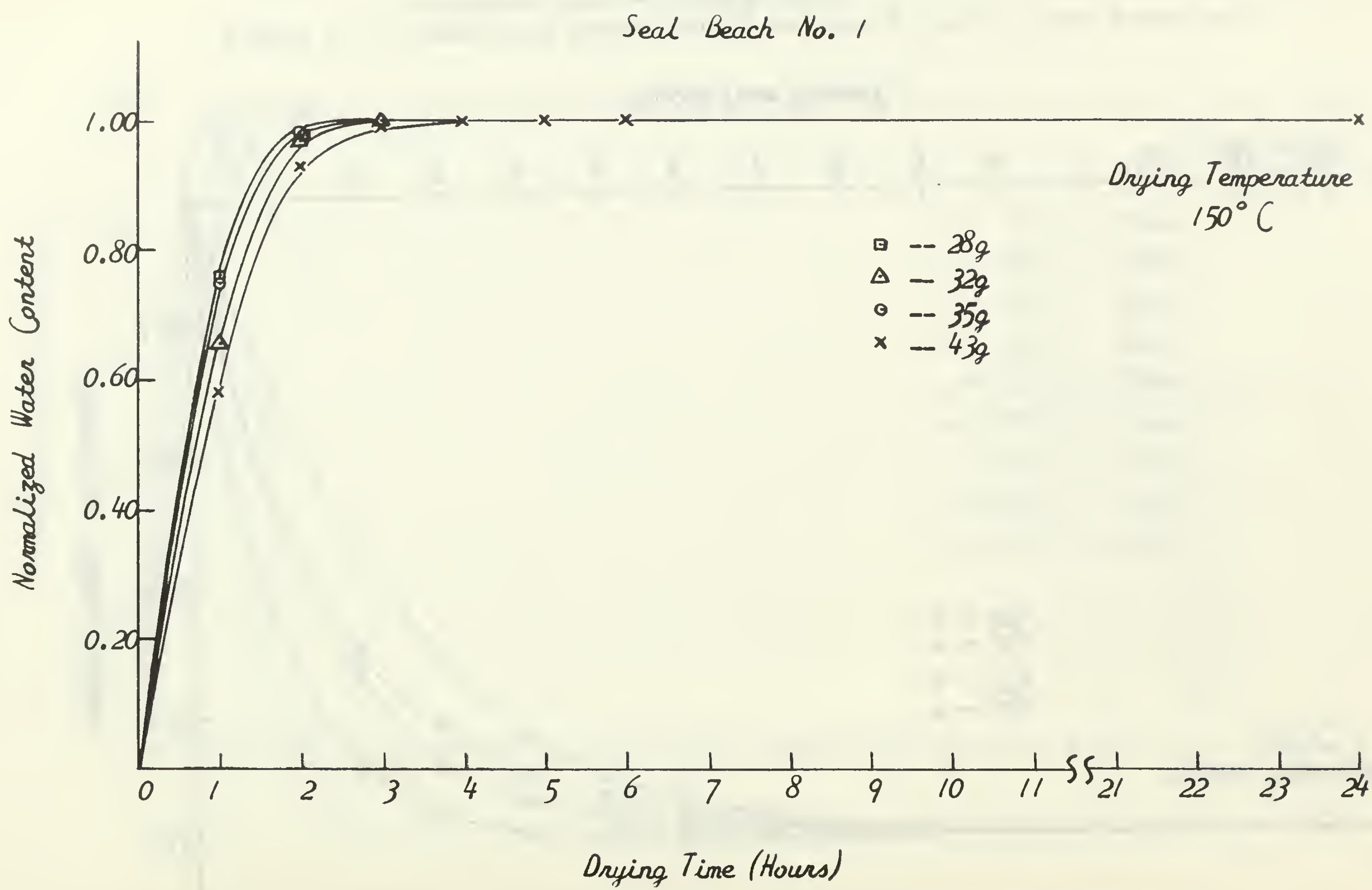

Figure 13. Normalized Water Content vs Drying Time for Seal Beach No. 1 at a Drying Temperature of 150°C

justification to accepting a drying temperature of $110 \pm 5^{o}C$ for terrestrial soils. This approach is now extended to marine sediments. Again the two distinct sample weight groups mentioned earlier are considered. Composite line graphs for the two weight groups showing the relationship between water content and drying temperature for the six sediments studied are shown in Figures 14 and 15. Each data point represents the water content for a given sediment at a given drying temperature within the temperature range considered. For purposes of clarity and to show the correlation between the two weight groups concerning the relationship between water content and drying temperature, Figures 16 through 18 are plotted. These figures show that the behavior of water content with drying temperature is similar for the two sample weights considered. A few large differences in the value of water content obtained at a given temperature are readily seen, however. Figure 15, for example, shows the radically differing values of water content obtained for the two weight groups in the drying temperature range of 130 to $150^{o}C$ for Elkhorn No. 2. If a large enough group of samples were considered for each weight group these extremes would probably be reduced such that a true general trend could be drawn for this relationship.

The maximum values of water content appear to occur at randomly differing drying temperatures for each of the sediments. This fact is not easily explained since Lambe found that the value obtained

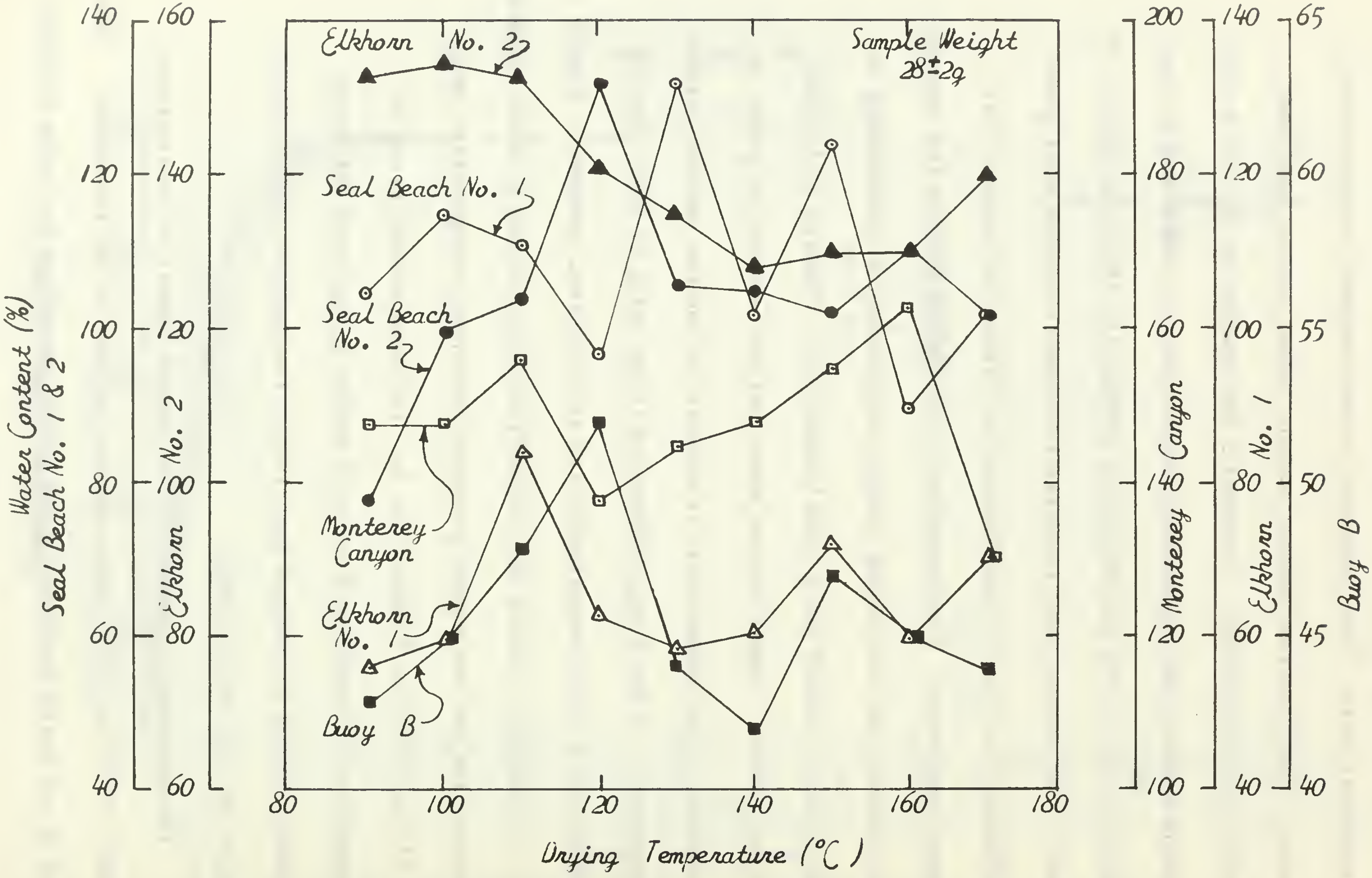

Figure 14. Water Content vs Drying Temperature for a Sample Weight of 28 ± 2g

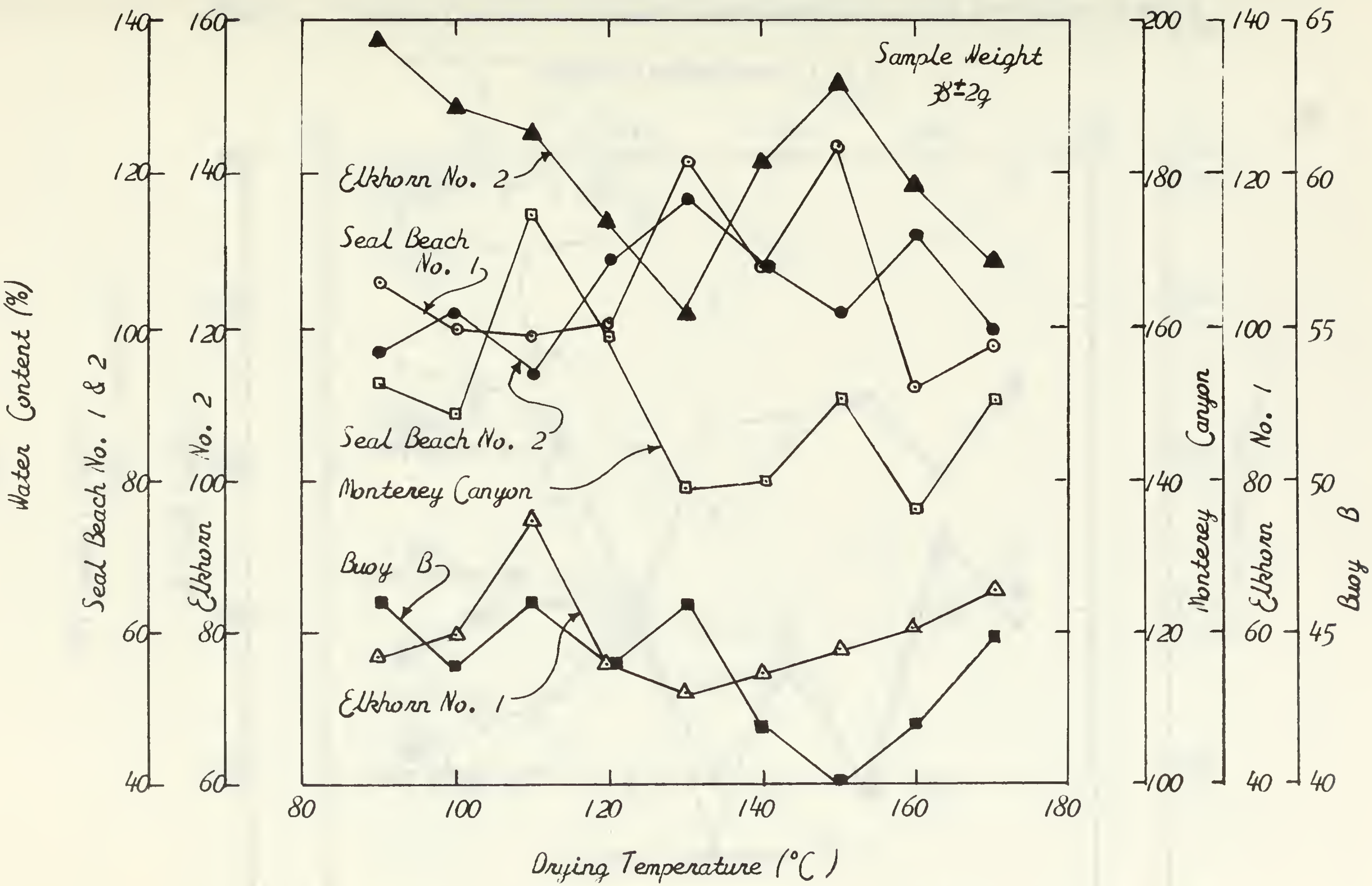

Figure 15. Water Content vs Drying Temperature for a Sample Weight of 38 $\pm$ 2g

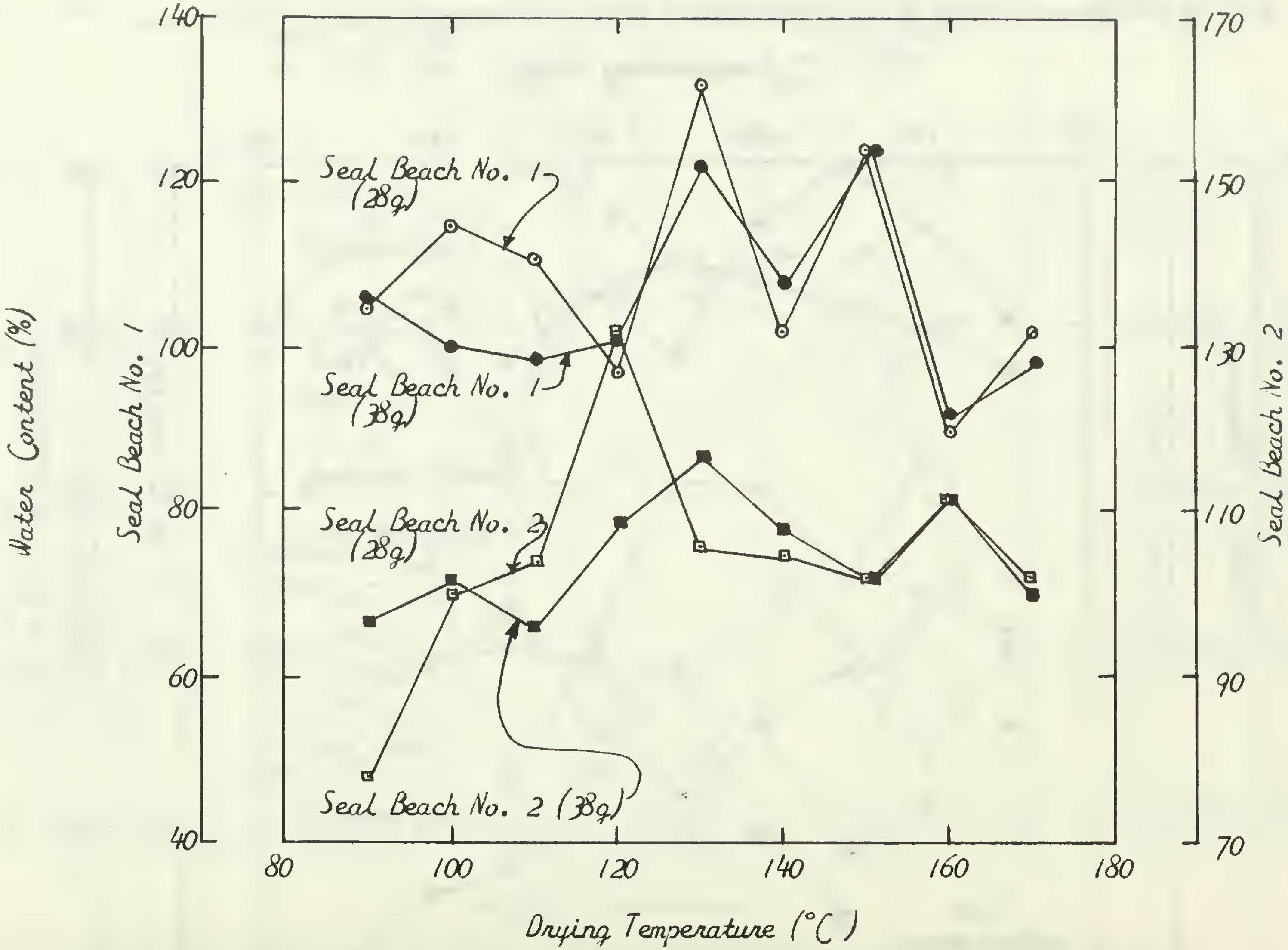

Figure 16. Water Content vs Drying Temperature for Seal Beach No. 1 and 2

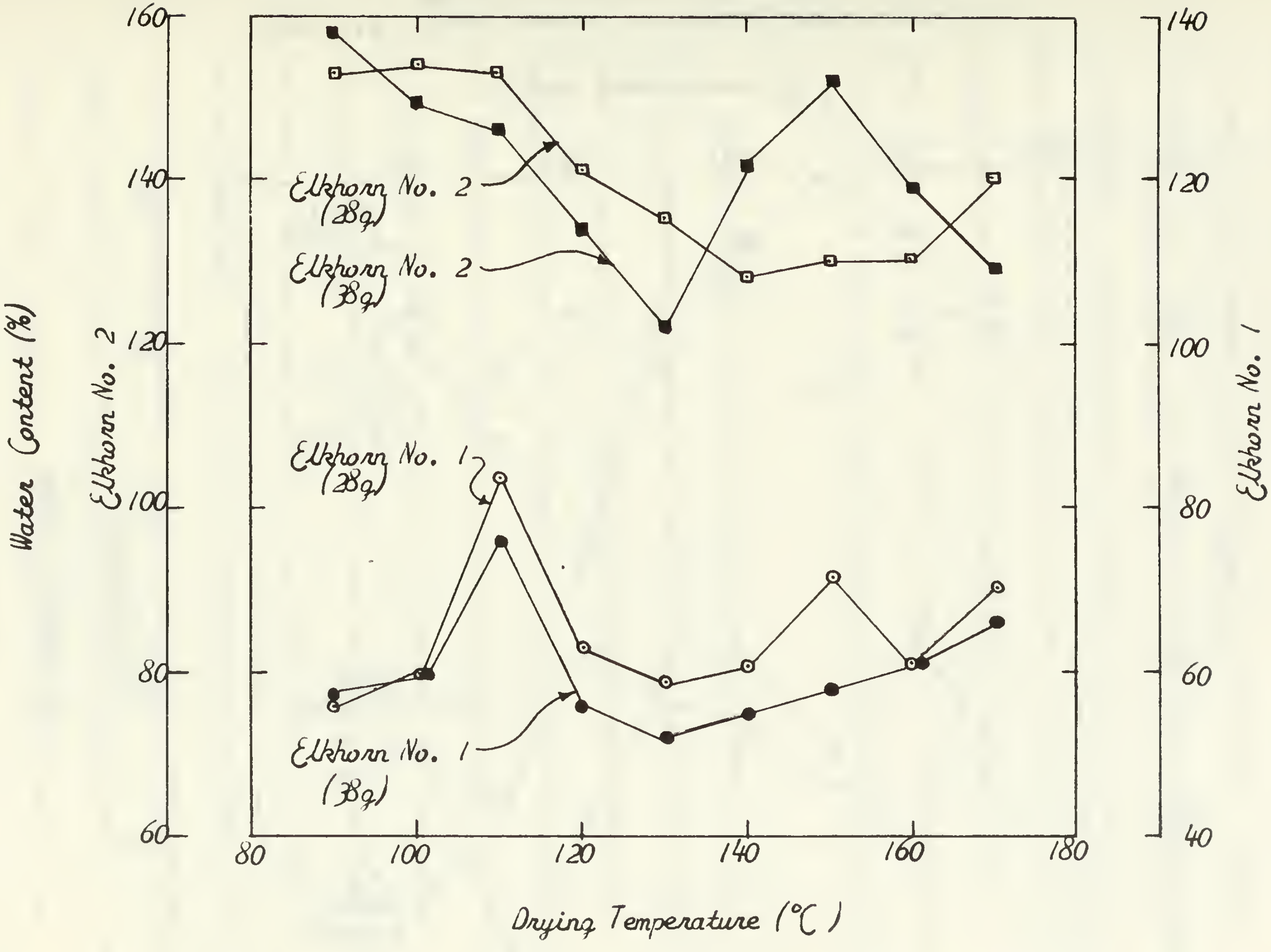

Figure 17. Water Content vs Drying Temperature for Elkhorn No. 1 and 2

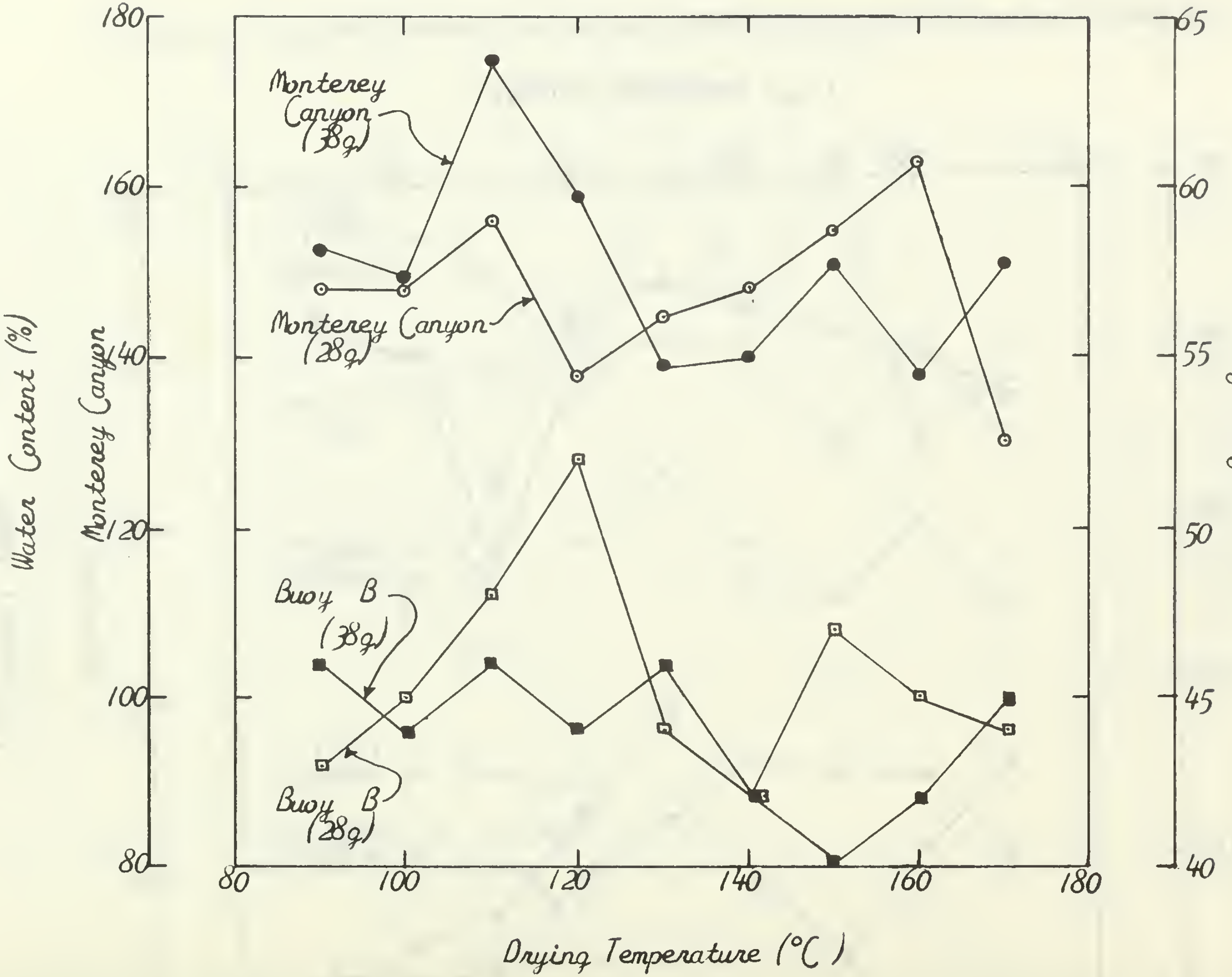

Figure 18. Water Content vs Drying Temperature for Monterey Canyon and Buoy B

for water content increased steadily with increase in the drying temperature. Again the relationship between the sediment structure and soluble salts appears to influence the value of water content obtained. This aspect is not completely understood although several investigators, namely Sullivan (1939) and Tschebotorioff (1955), have shown that certain ions such as Na^+ tend to form a thick film of absorbed water around soil crystals. Since sea water has NaCl as its principal salt, the water content of a marine sediment is likely to be higher than that of a similarly structured terrestrial soil.

The above phenomenon accounts for the high water content of marine sediments, but does not satisfactorily explain the random behavior concerning the relationship between water content and drying temperature. The change in the chemistry and mineralogy that apparently occurs within a sediment when subjected to different drying temperatures is not clearly understood. The temperature dependent drying process possibly permits the exchange of certain ions within the sediment structure that would not occur under natural conditions. Grim (1962) has shown that the plastic clays such as montmorillonite and illite are most succeptable to ionic changes within their structure. Thus no satisfactory explanation as to the sporadic behavior of marine sediments when subjected to oven drying can be drawn from this consideration.

4. Water Content Versus Sample Weight

The final relationship considered was that of water content versus sample weight. A fairly large scattering of data points was obtained for this relationship. A straight least square regression line was fitted to the data as shown in Figures 19 through 24. These lines were determined by solving the following pair of simultaneous normal equations:

$$Y = a_o N + a_1 \sum X$$
$$XY = a_o \sum X + a_1 \sum X^2 \qquad (4)$$

where

X = sample weight

Y = water content

N = number of data points

a_o = Y - intercept

a_1 = slope of the straight line

By tabulating and summing the individual quantities X, Y, XY, and X^2 the desired quantities, $\sum X$, $\sum Y$, $\sum XY$, $\sum X^2$ of Table 1 were determined. Substituting these results in equation (4) and solving the pair of normal equations simultaneously yielded an equation for the least square regression line of the form:

$$Y = a_o + a_1 X \qquad (5)$$

where

X, Y, a_o and a_1 are as given for equation (4).

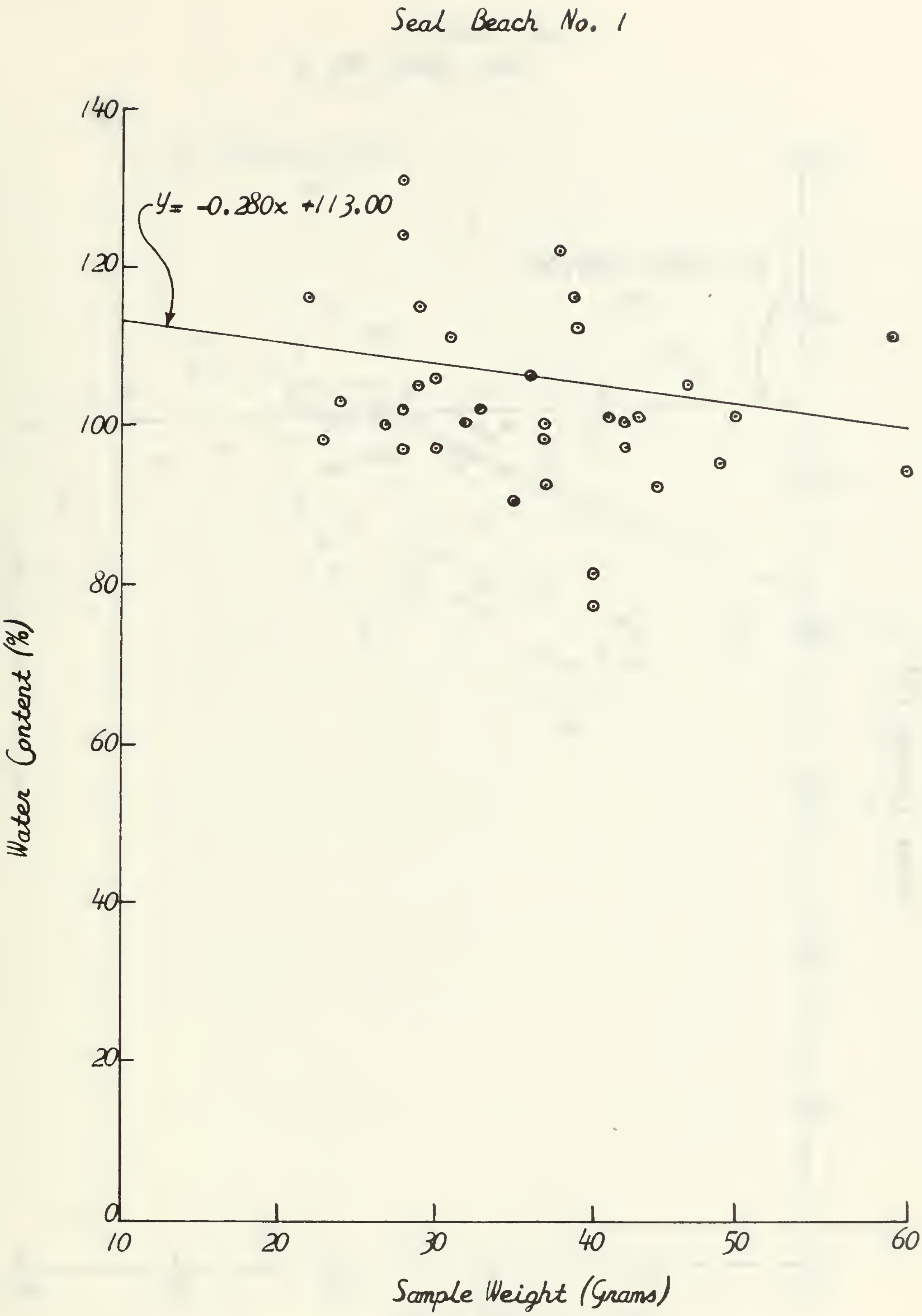

Figure 19. Water Content vs Sample Weight for Seal Beach No. 1

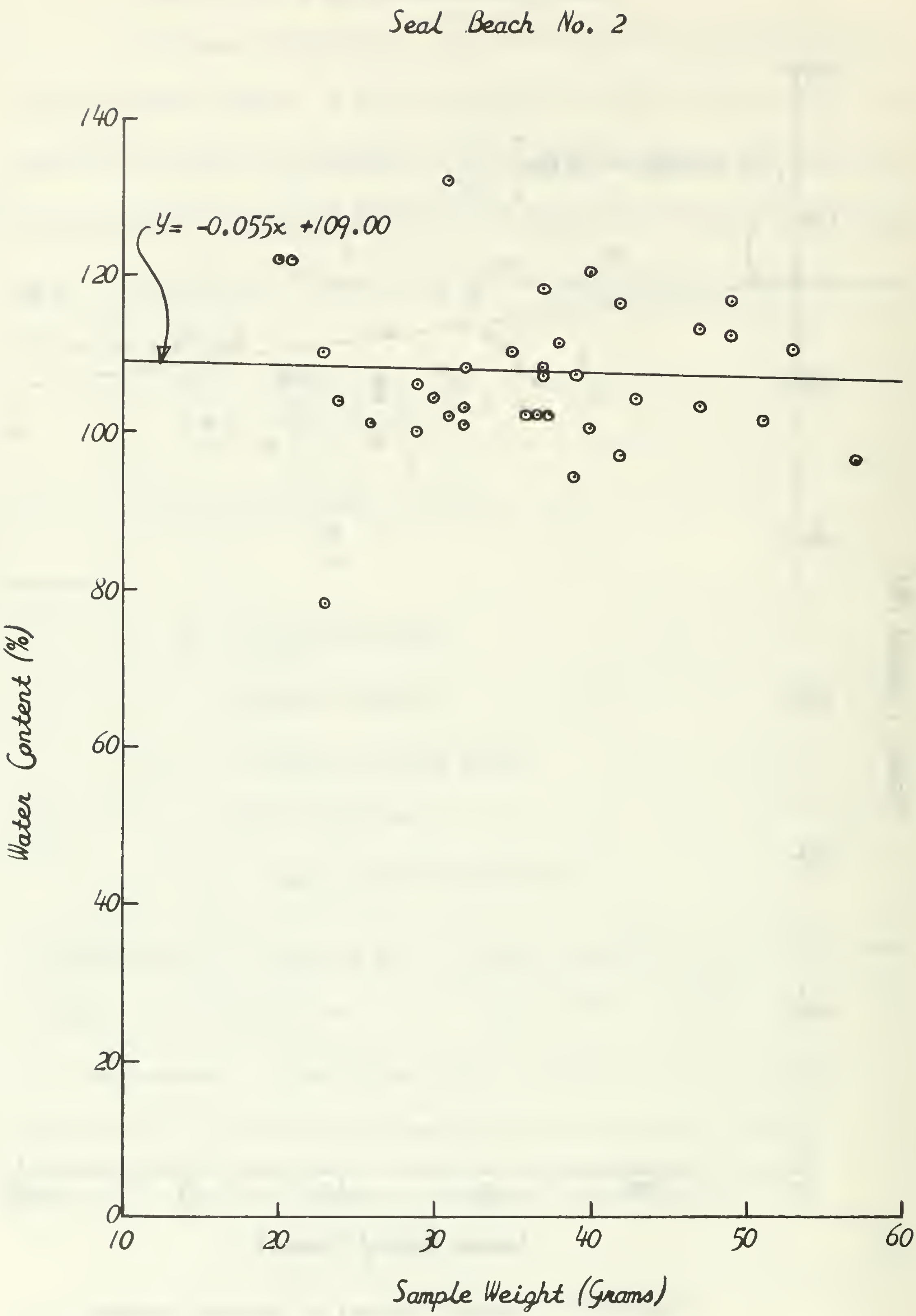

Figure 20. Water Content vs Sample Weight for Seal Beach No. 2

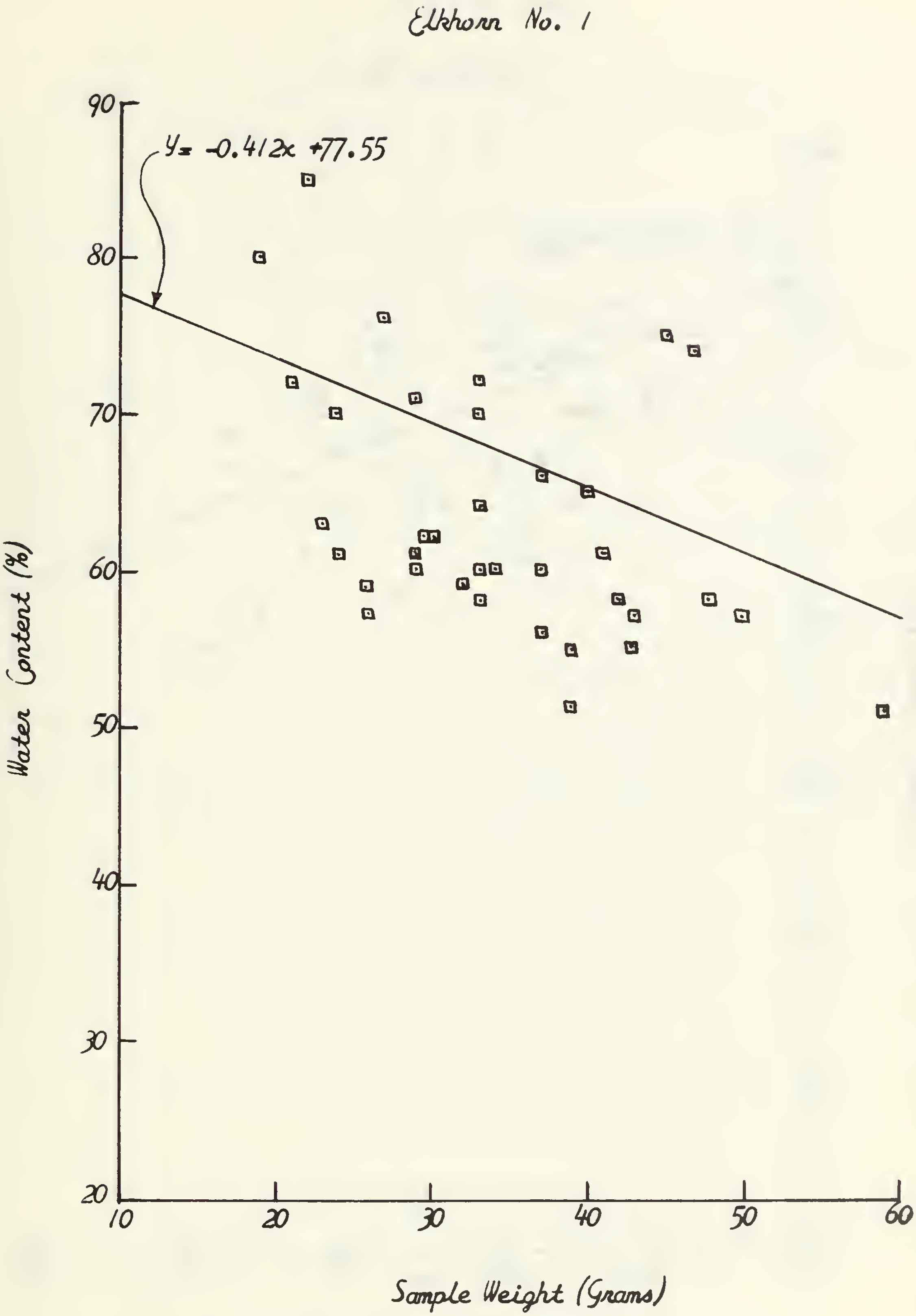

Figure 21. Water Content vs Sample Weight for Elkhorn No. 1

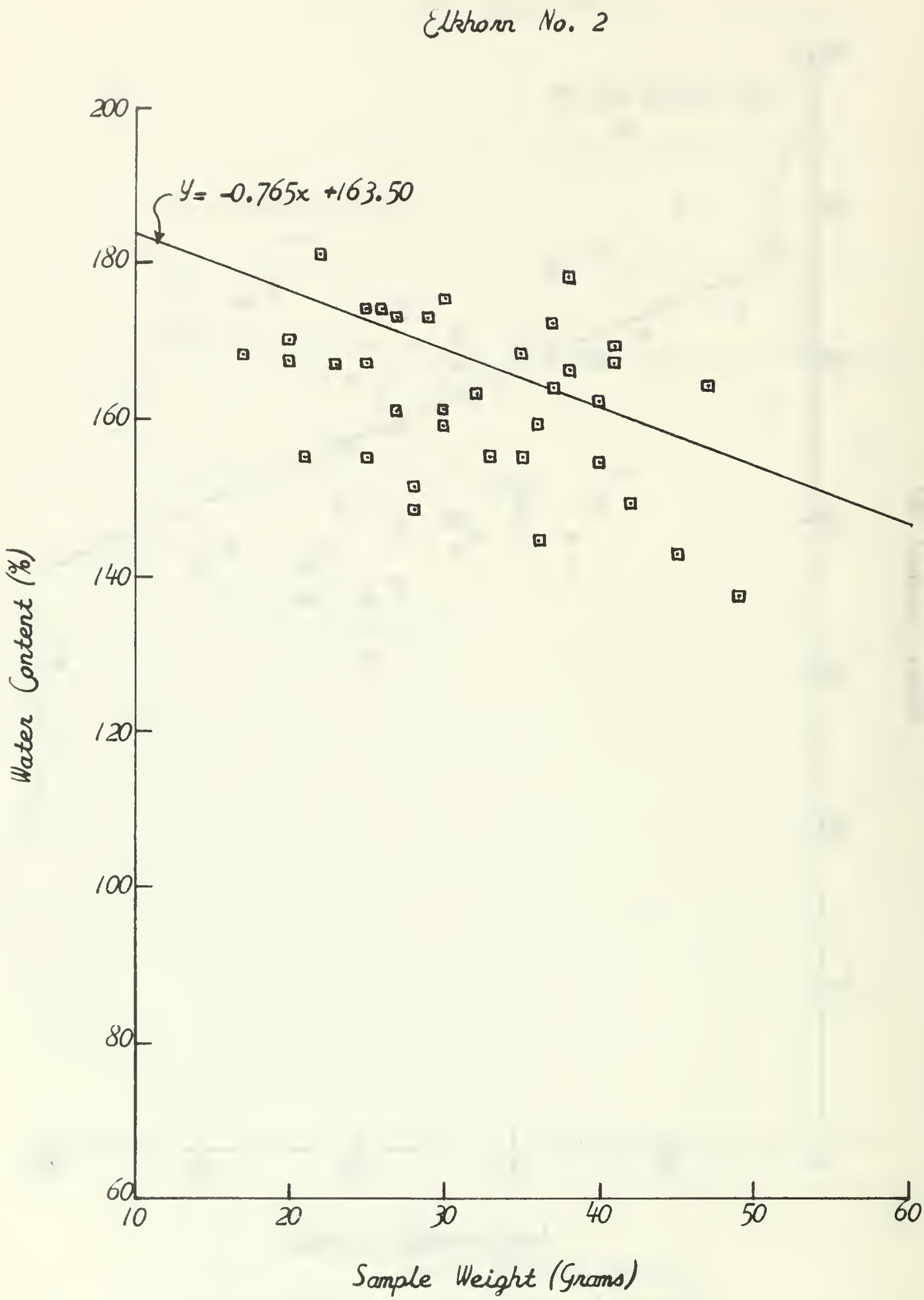

Figure 22. Water Content vs Sample Weight for Elkhorn No. 2

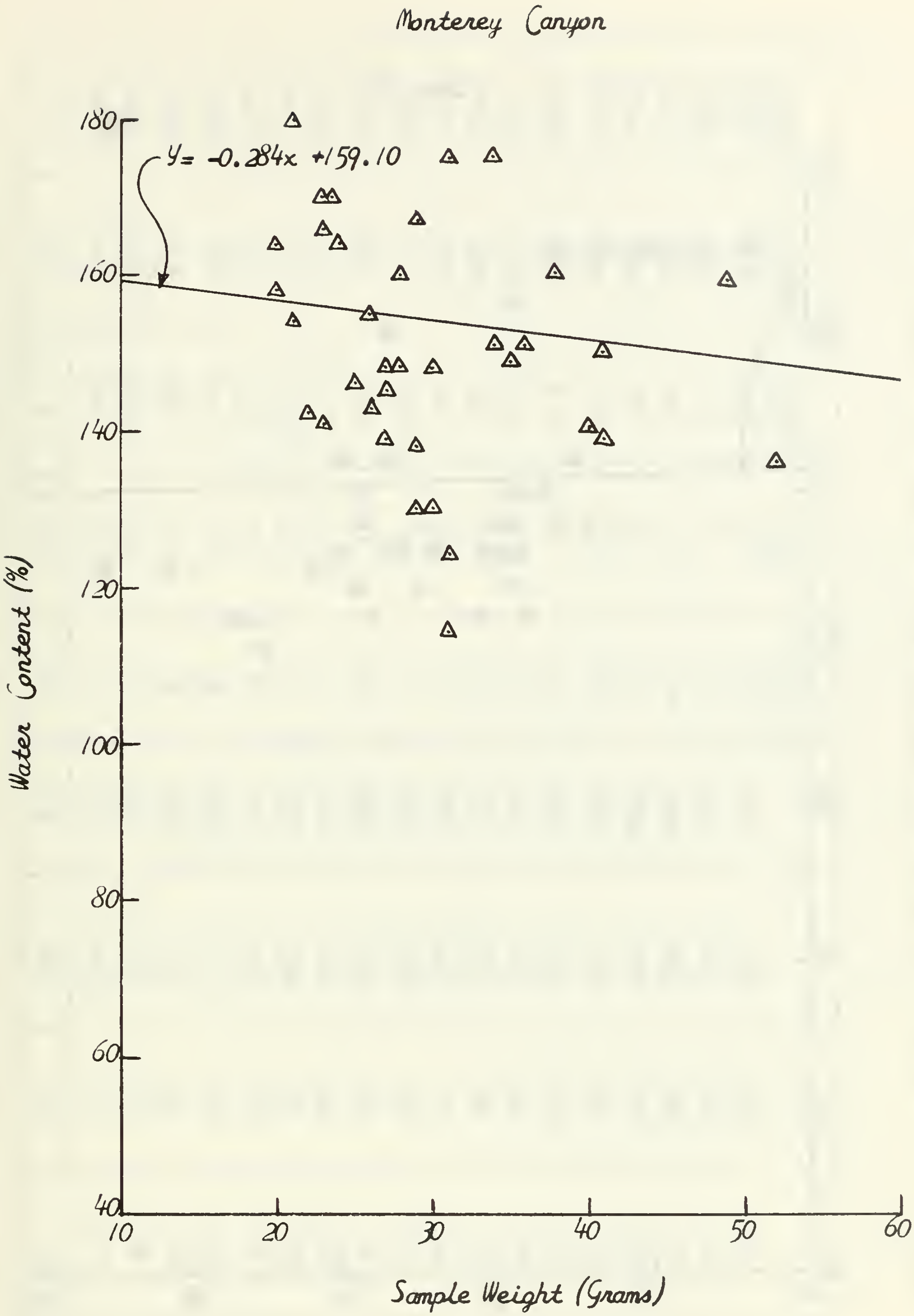

Figure 23. Water Content vs Sample Weight for Monterey Canyon

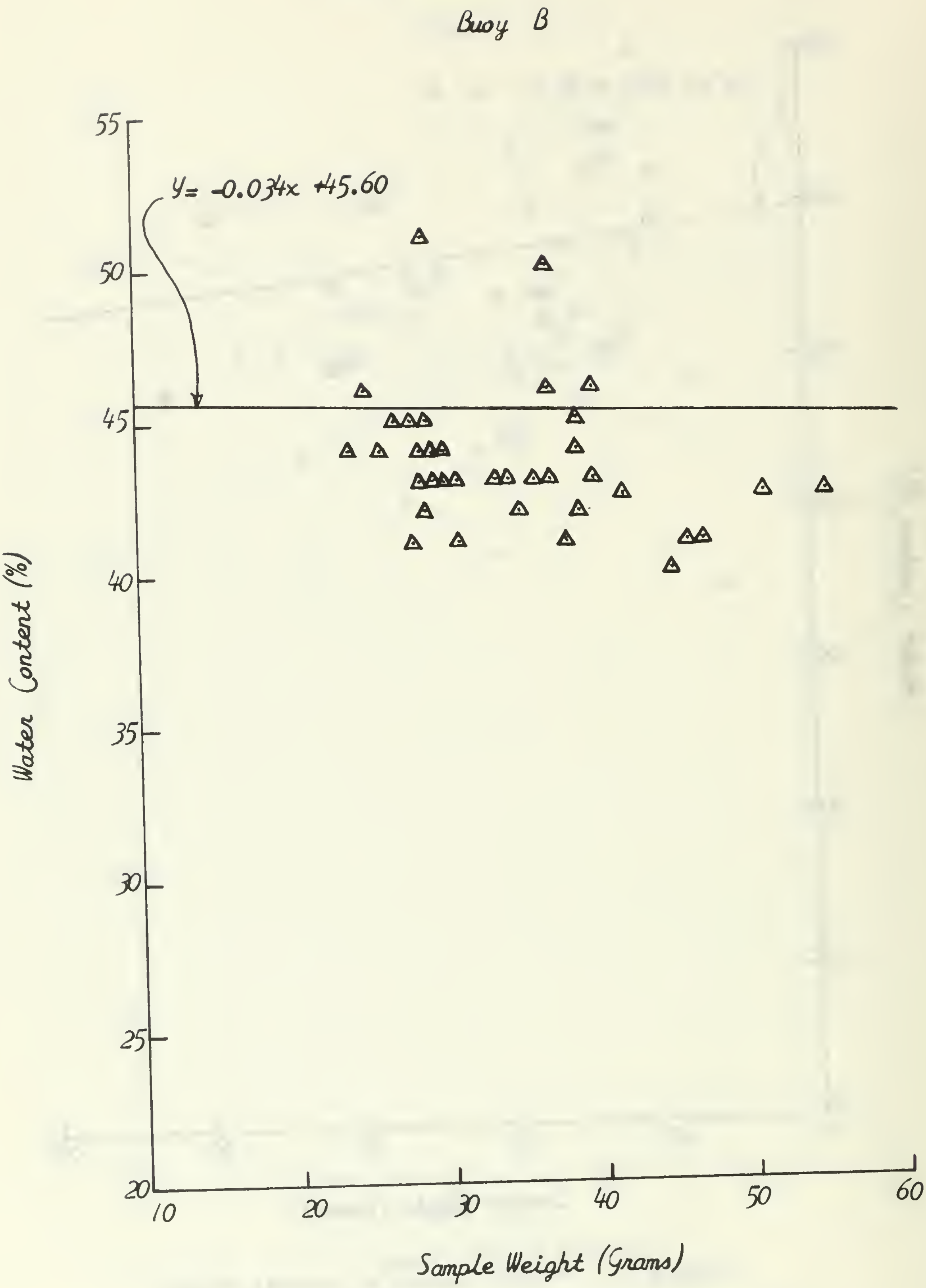

Figure 24. Water Content vs Sample Weight for Buoy B

X	y	X^2	Xy	y^2	X	y	X^2	Xy	y^2
22	112	484	2464	12544	37	100	1369	3700	10000
23	98	529	2254	9604	37	98	1369	3626	9604
24	103	576	2472	10609	37	92	1269	3404	8464
27	100	729	1700	10000	38	122	1444	4636	14884
28	131	784	3668	17161	39	112	1521	4368	12544
28	124	784	3472	15376	39	108	1521	4212	11664
28	102	784	2856	10404	40	91	1600	3640	8281
28	97	784	2716	9409	40	87	1600	3480	7569
29	115	841	3335	13225	41	101	1681	4141	10201
29	105	841	3045	11025	42	100	1764	4200	10000
29	90	841	2610	8100	42	97	1764	4074	9409
30	106	900	3180	11236	43	101	1849	4343	10201
30	97	900	2910	9409	44	92	1936	4048	8464
31	111	961	3441	13321	46	105	2116	4830	11025
32	100	1024	3200	10000	48	95	2304	4560	9025
33	102	1089	3366	10404	49	101	2401	4949	10201
35	90	1225	3150	8100	59	112	3381	6608	12544
36	106	1296	3816	11236	62	94	3844	5828	8836
					1305	3697	50215	133302	384079

Table 1. Tabulation of Variables for Least Square Regression Line Determination

Least Square Regression Line is given by:

$$Y = a_o N + a_1 \sum X$$

$$XY = a_o \sum X + a_1 \sum X^2$$

$$(3697 = 36a_o + 1305a_1)\ 36.25$$

$$133302 = 1305a_o + 50215a_1$$

$$134016 = 1305a + 47306a$$

$$-133302 = -1305a - 50215a$$

$$814 = -2909a_1 \quad \text{or } a_1 = \frac{-814}{2909} = \underline{-0.280}$$

$$133302 = 1305a_o + 50215(-0.280)$$

$$\text{or } a_o = \frac{133302 + 14060}{1305} = \frac{147362}{1305} = \underline{113.00}$$

$$\underline{Y = -0.280X + 113.00}$$

Correlation Coefficient is given by:

$$= \frac{N\sum XY - (\sum X)(\sum Y)}{\{[N\sum X^2 - (\sum X)^2][N\sum Y^2 - (\sum Y)^2]\}^{1/2}}$$

$$= \frac{36(133302) - (1305)(3697)}{\{[36(50215) - (1305)^2][36(384079) - (3697)^2]\}^{1/2}}$$

$$= \frac{4,798,872 - 4,824,585}{\{[1,807,740 - 1,703,025][13,826,844 - 13,667,809]\}^{1/2}}$$

$$= \frac{-25,713}{\{[104,715][159,035]\}^{1/2}}$$

$$= \frac{-25,713}{(16,653,350,025)^{1/2}}$$

$$= \frac{-25,713}{129,100}$$

$$= \longrightarrow \underline{-0.199}$$

Table 2. Least square regression line and correlation coefficient determined.

A least square regression line then was determined for the relationship in question for each of the six sediments analyzed.

A measure of how well such a straight line relationship fits a given set of data is expressed by the correlation coefficient. Using the short computational formula of Spiegel (1961), the correlation coefficient r is given by:

$$r = \frac{N \sum XY - (\sum X)(\sum Y)}{[N \sum X^2 - (\sum X)^2][N \sum Y^2 - (\sum Y)^2]} \tag{6}$$

where the variables are as defined for equation (4). The correlation coefficient was determined to check the validity of the least square regression line representation for the indicated relationship. This coefficient was found to vary from a high of -0.786 to a low of -0.051. While the straight line relationship appears to fit the data quite well for several of the cases, it is inadequate for the others. It is unlikely that a second or third degree least square polynomial would fit the given data any better than the straight line relationship. This fact may be surmised from the discussion of the previous section where the role of the base exchange of ions was felt to control to some degree the water content of a given sub-sample. The treatment of this relationship demonstrates that water content apparently decreases with increase in sample weight. Possibly the dissolved salts play an important role here.

E. FINDINGS OF GRAIN SIZE ANALYSES AND CARBON DETERMINATIONS

The results of the grain size analyses are expressed as a function of grain size in millimeters and percent of dry fraction by weight as shown in Figures 25 through 30. These distribution curves were then analyzed to give the sand-silt-clay ratio using the Wentworth classification scale for demarcation. The results were then plotted on the tertiary diagram of Figure 31 based on the work of Shepard (1954). Each of the six sediment samples was therefore classified according to grain size. For example, Seal Beach No. 1 is classified as a clayey silt.

Findings of the carbon determinations are summarized in Table 3. The results clearly show that organic matter was not present in a significant quantity in the sediment samples tested. Organic carbon was found to be considerably higher in the Elkhorn No. 2 and Monterey Canyon samples then in the other four sediments tested. The Elkhorn sample was suspected of having a higher organic carbon content since it was obtained from a calm portion of the estuary that had been collecting marine debris for some time. Here bacteria have been permitted to act under ideal conditions reducing carbon particulate matter to clay and silt size particles. A similar condition exists in the portion of Monterey Canyon sampled. Additionally the canyon serves as the collecting basin for the results of bacterialogical action that occur in shallower

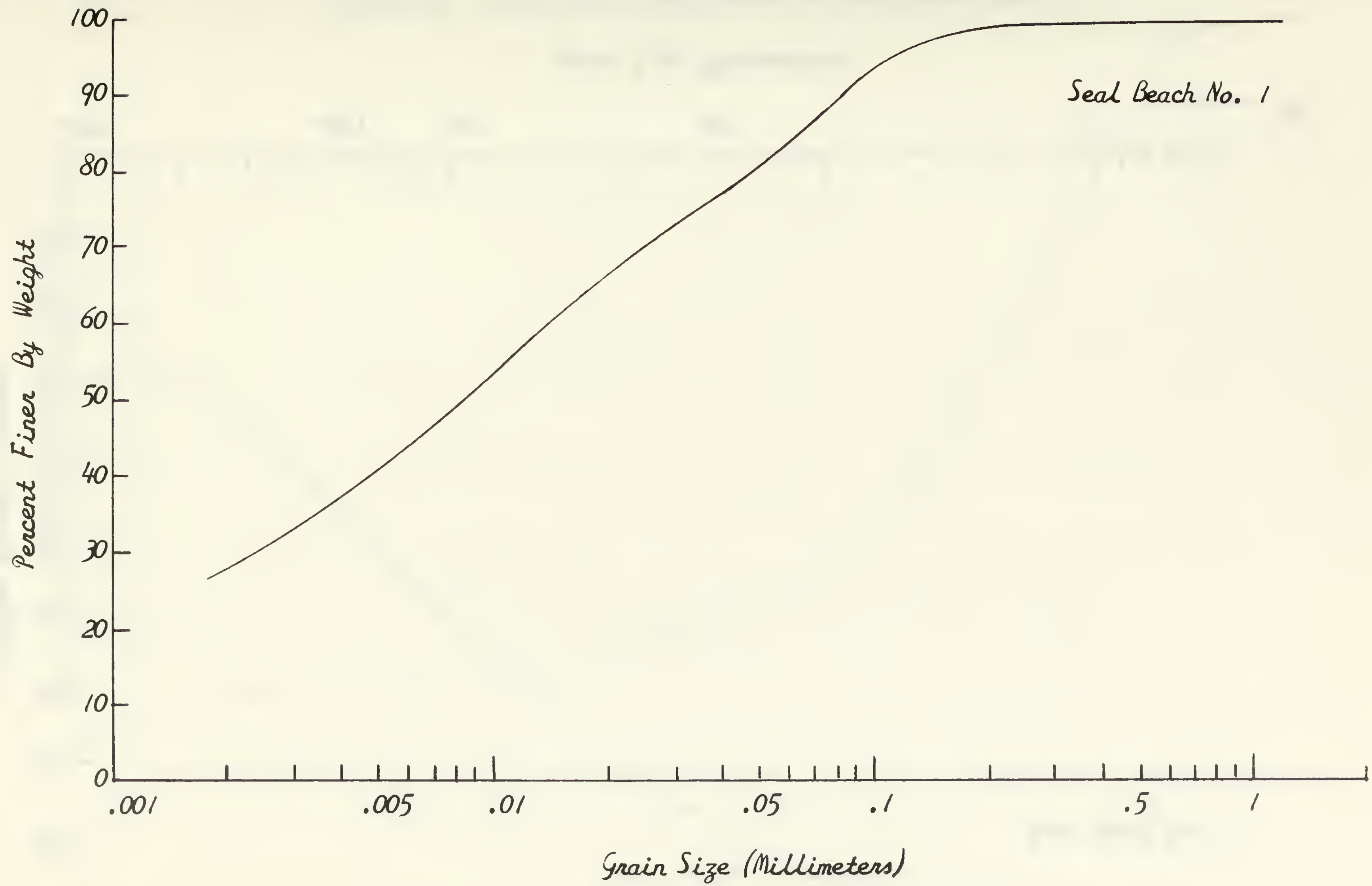

Figure 25. Grain Size Distribution for Seal Beach No. 1

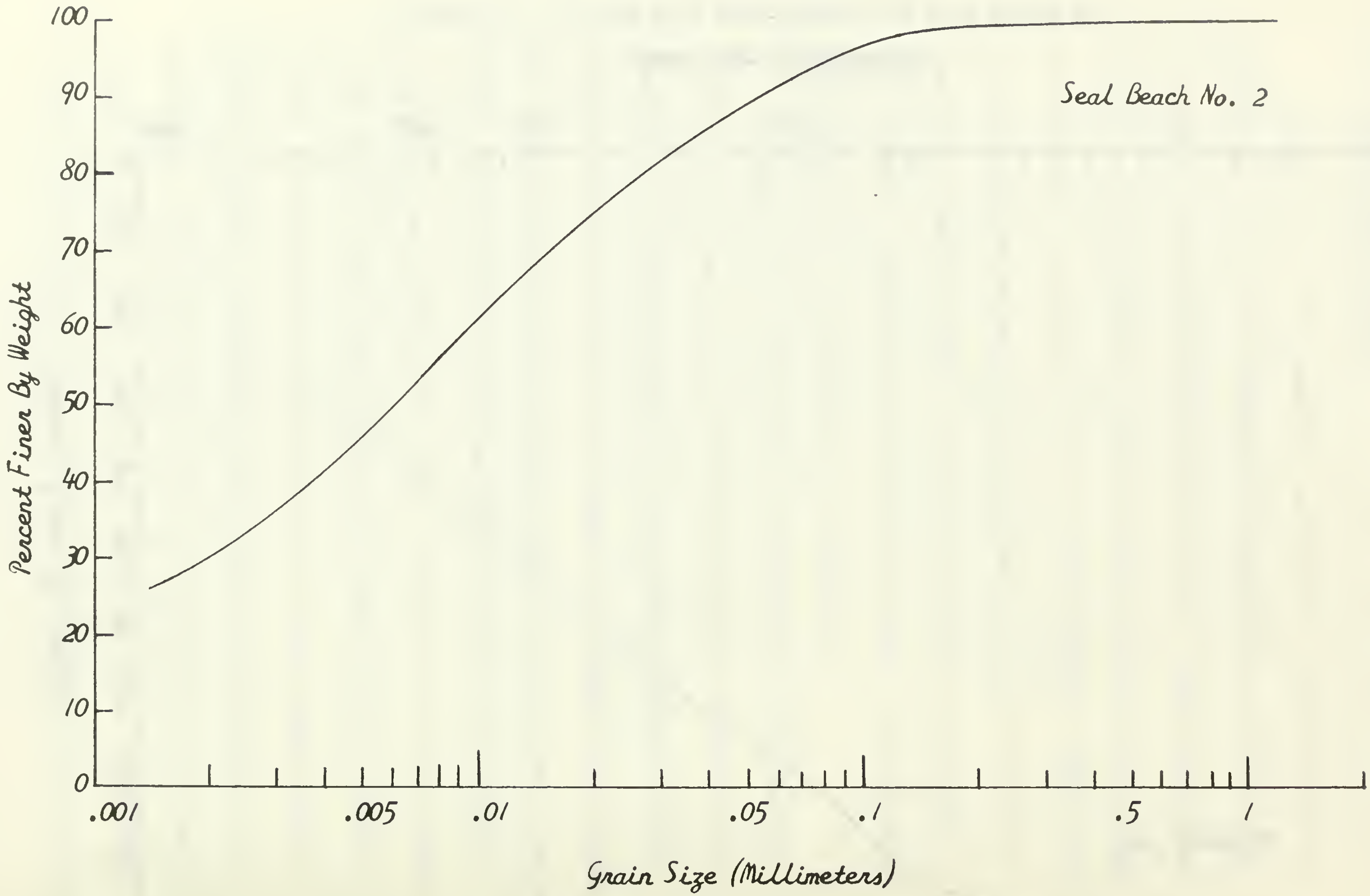

Figure 26. Grain Size Distribution for Seal Beach No. 2

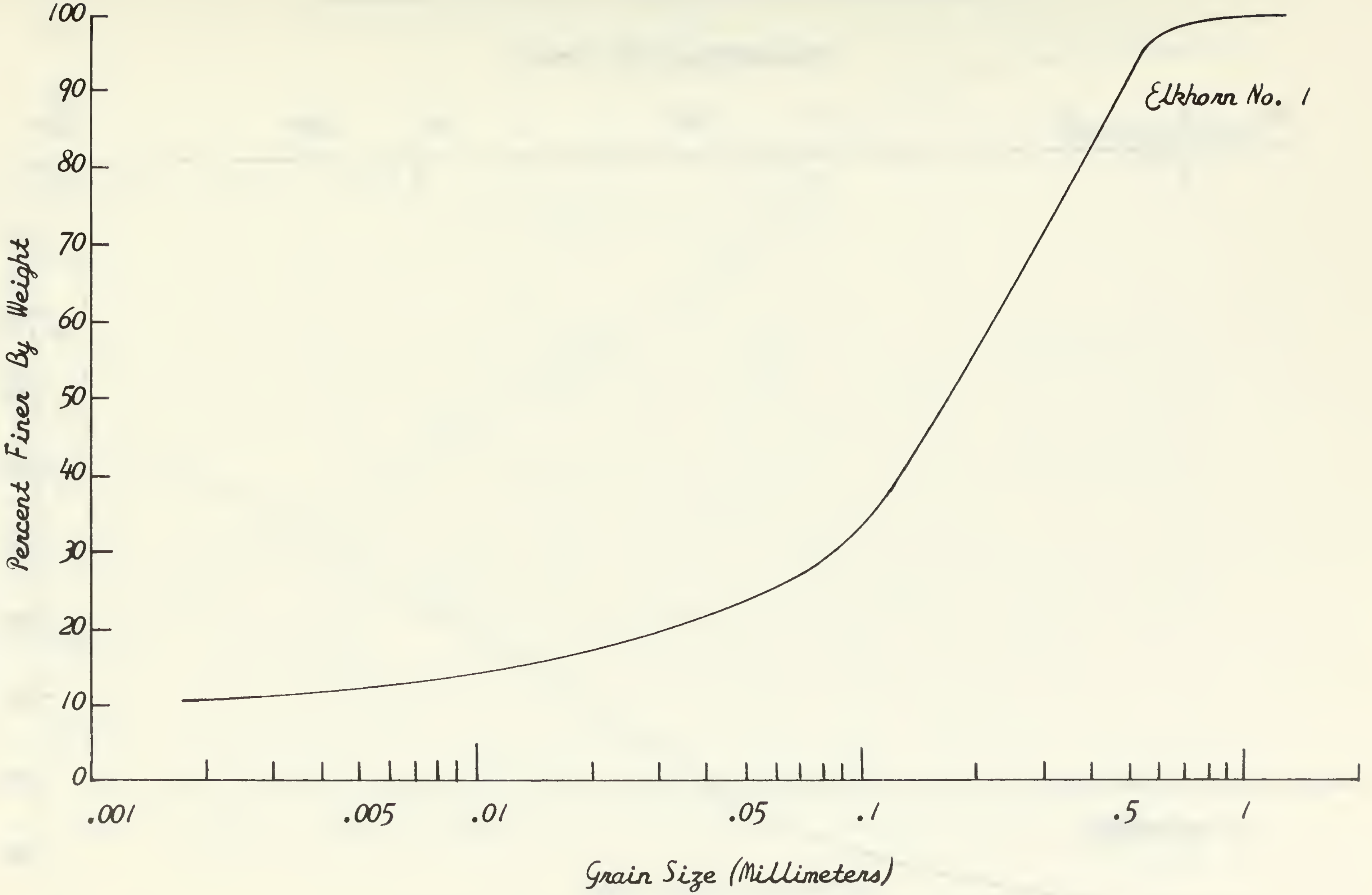

Figure 27. Grain Size Distribution for Elkhorn No. 1

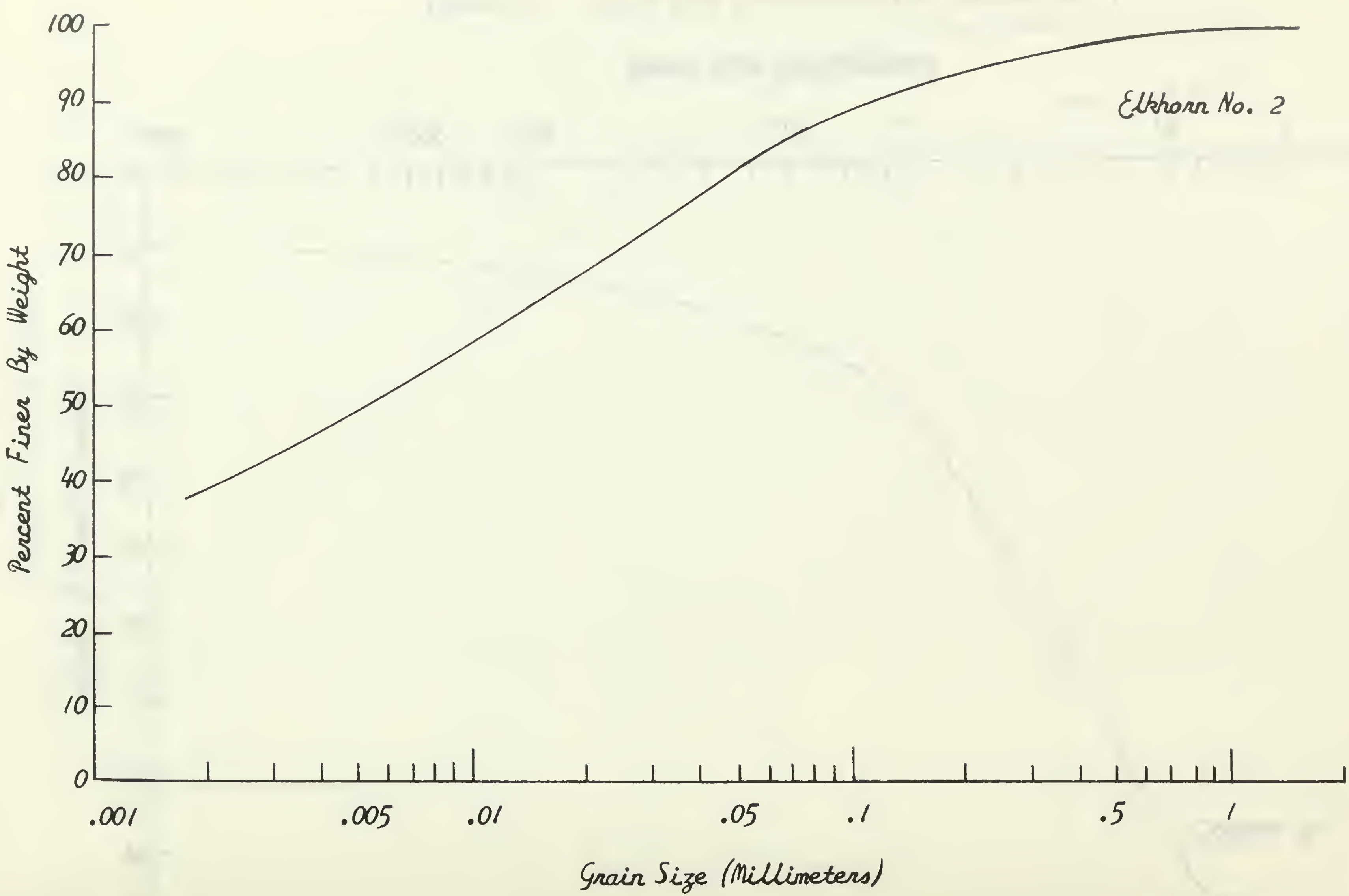

Figure 28. Grain Size Distribution for Elkhorn No. 2

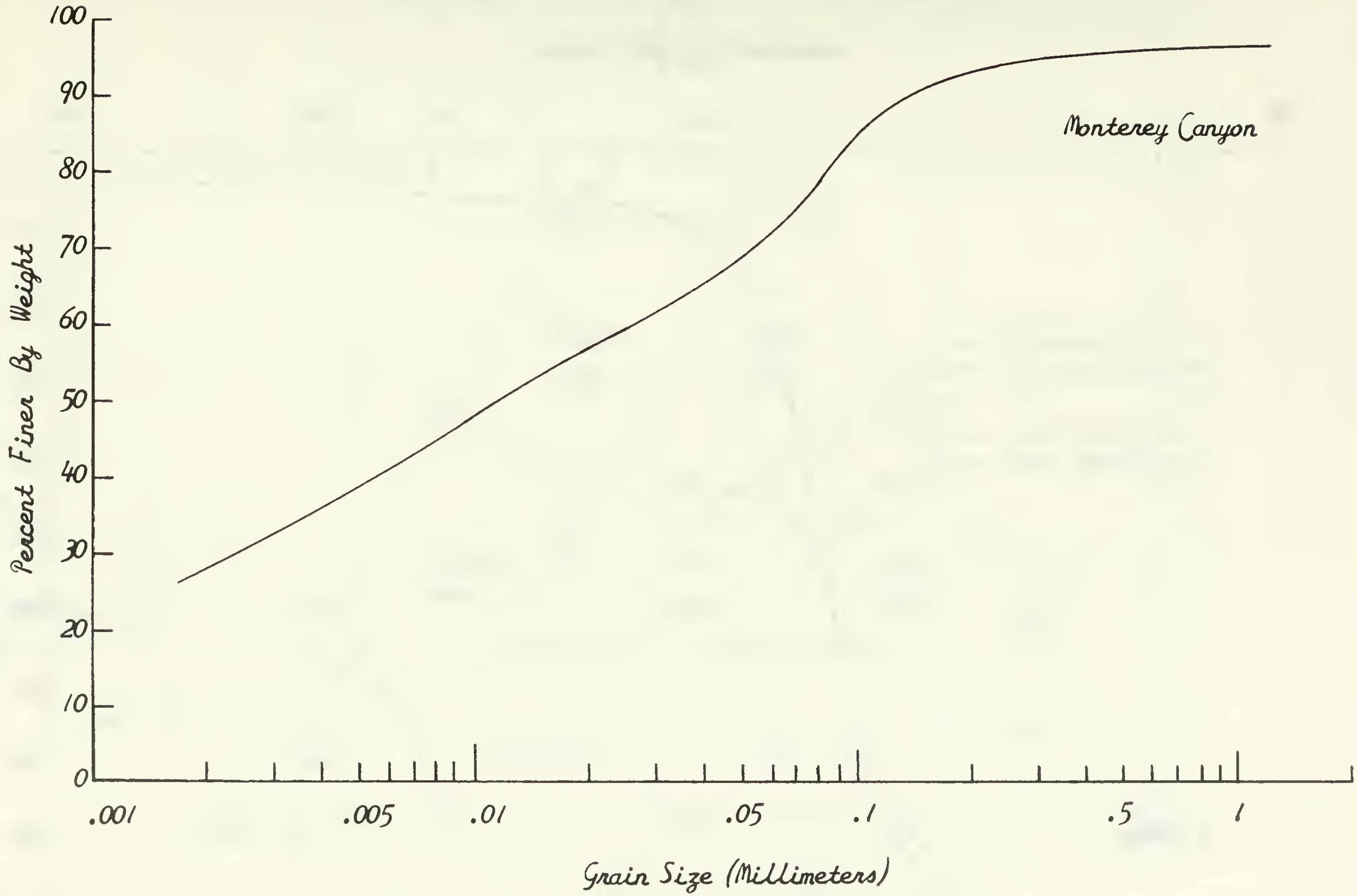

Figure 29. Grain Size Distribution for Monterey Canyon

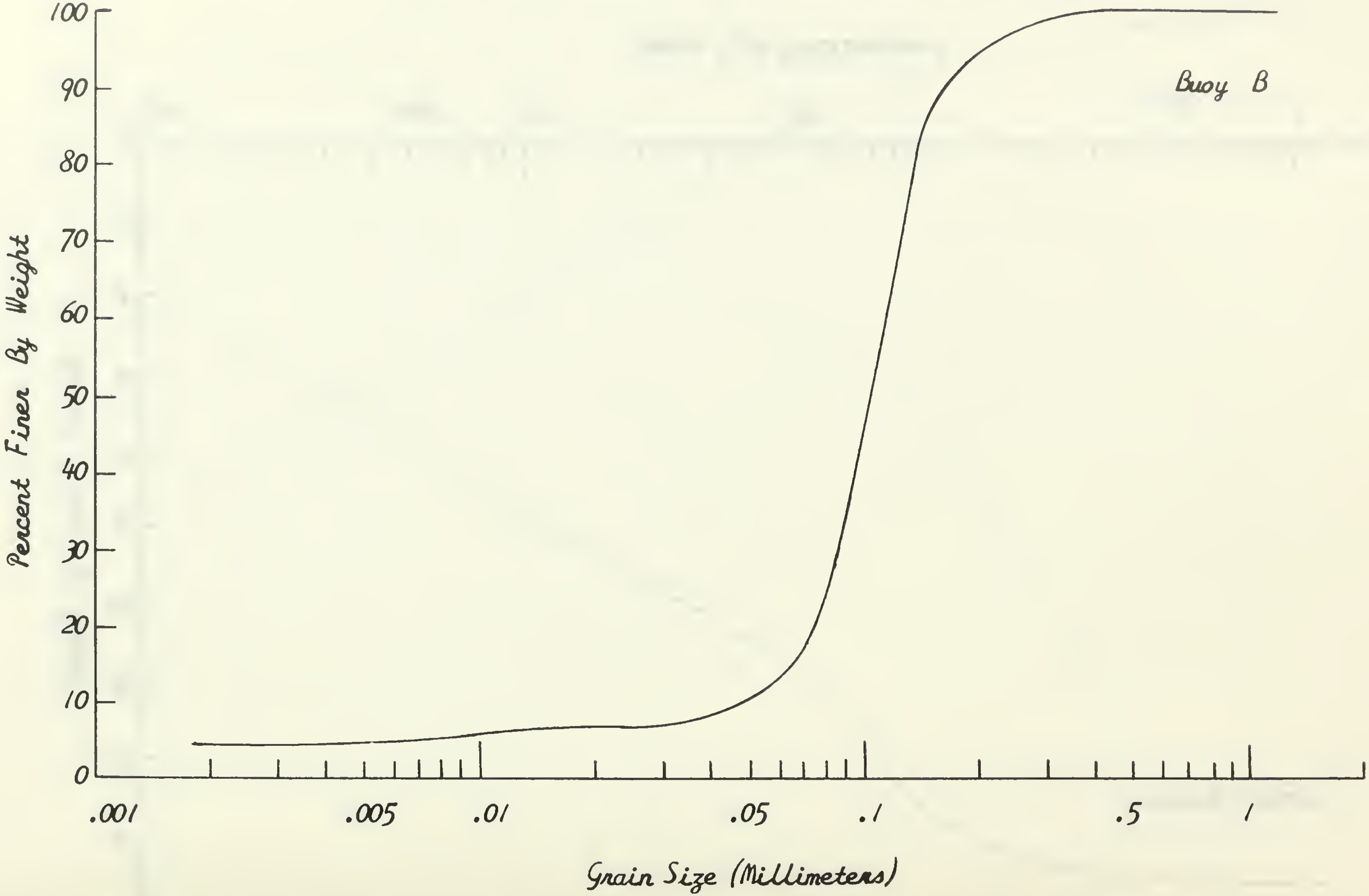

Figure 30. Grain Size Distribution for Buoy B

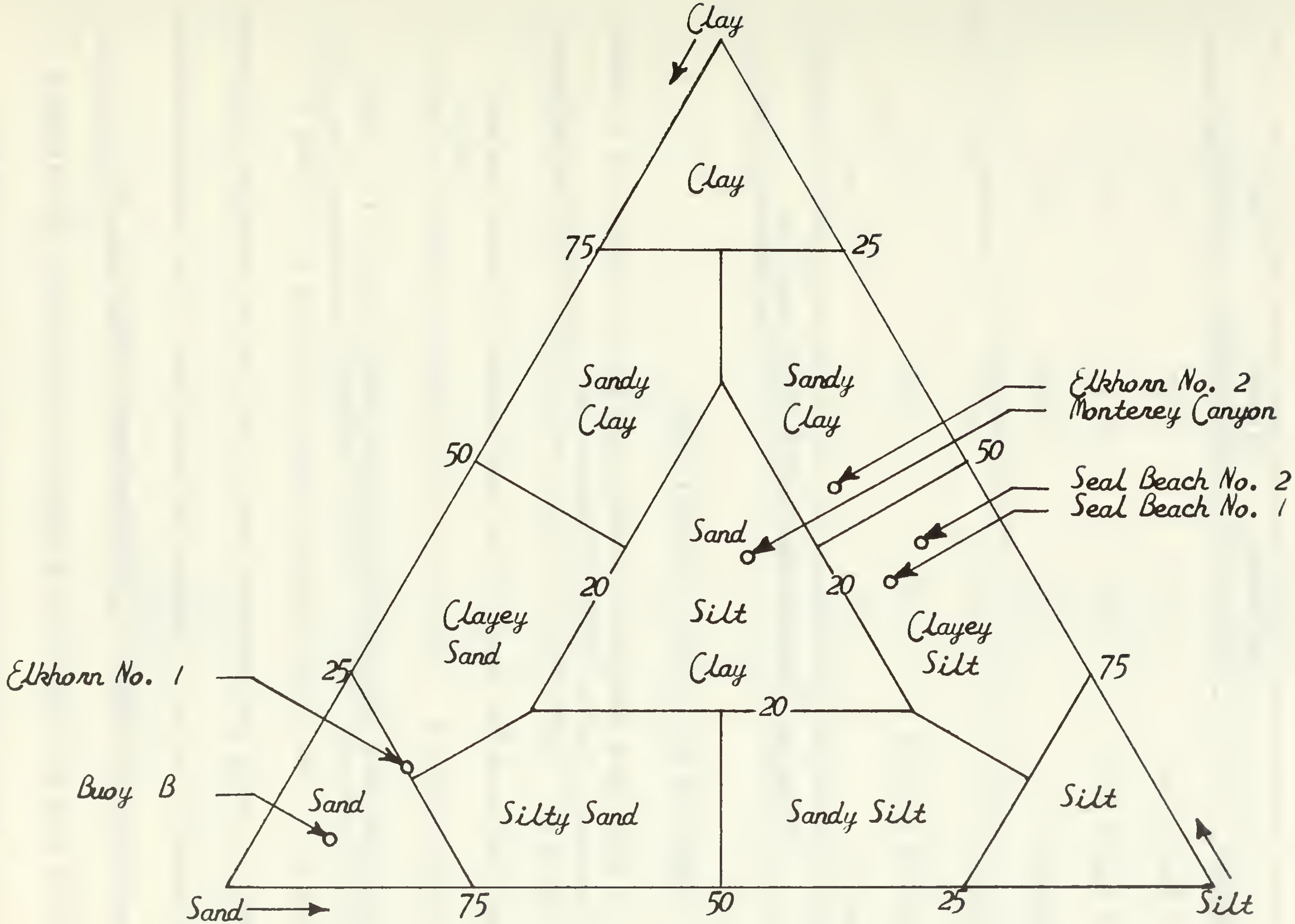

Figure 31. Tertiary Classification Diagram

water. The low concentration of carbonate carbon possibly suggests that little marine shell life exists in the areas sampled.

Sediment	Carbonate carbon (%)	Organic carbon (%)	Total carbon (%)
Seal Beach No. 1	0.17	0.48	0.65
Seal Beach No. 2	0.20	0.47	0.67
Elkhorn No. 1	0.07	0.59	0.66
Elkhorn No. 2	0.23	1.54	1.77
Monterey Canyon	0.52	1.24	1.76
Buoy B	0.11	0.35	0.46

Table 3. Results of Carbon Determinations

F. RESULTS OF X-RAY DIFFRACTION

A trace was obtained for each of the six sediments and is shown in Figure 32. Unfortunately only a few minerals could be identified. Identification of the clay fraction was possible in two of the six sediments studied. This result is not surprising since only three of the sediments contained a significant clay fraction, i.e., Seal Beach No. 1 and 2 and Monterey Canyon (Figures 25, 26 and 29). Table 4, listing the minerals found in each of the samples, facilitates interpretation of the composite diffractogram. The prominent peaks, where they first appear beginning with Seal Beach No. 1, are marked with the respective d-spacing in Angstroms (Å) centered over the spike. The d-spacings were found by converting the

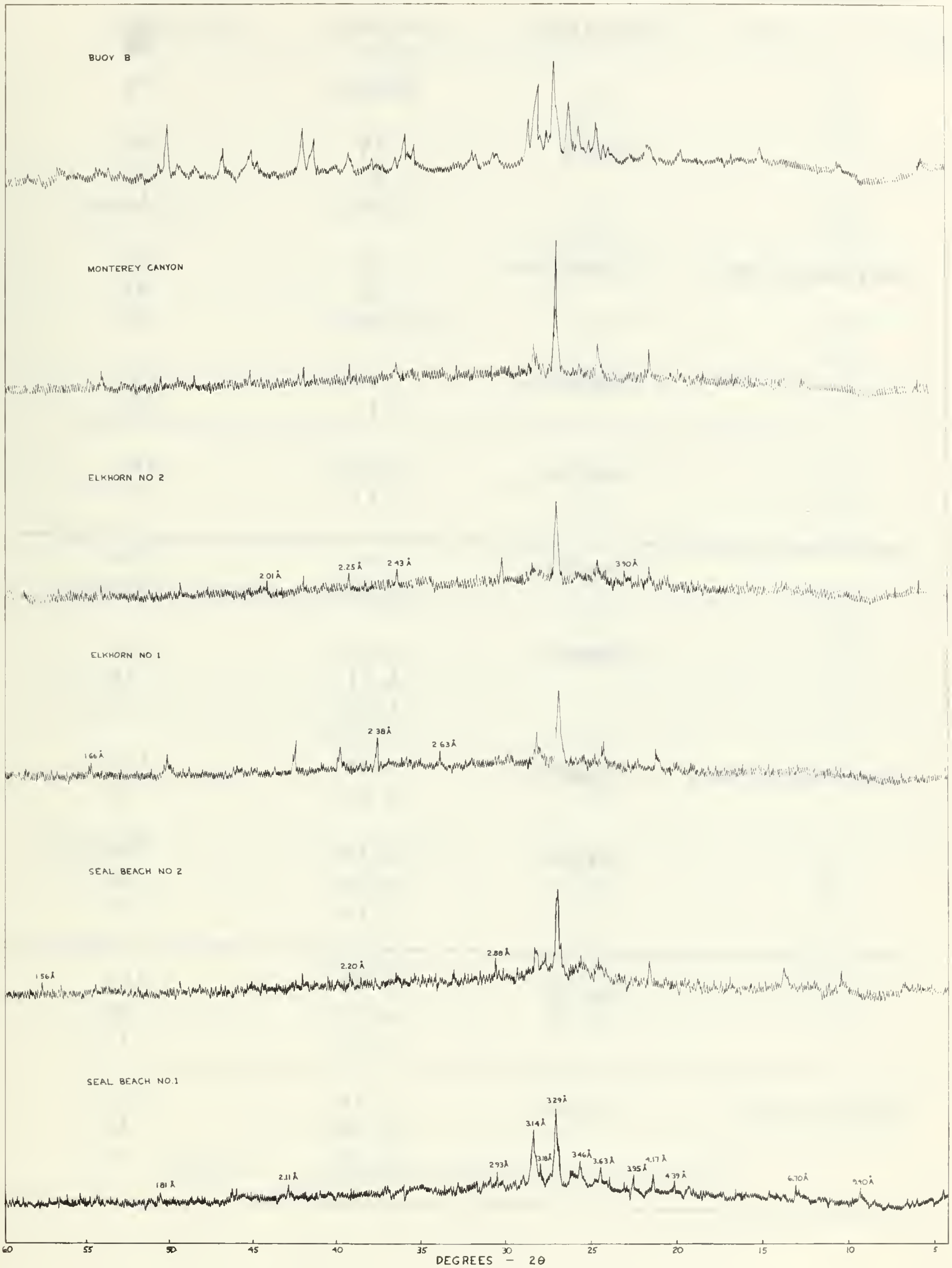

Figure 32. Composite X-ray Diffractogram

SEDIMENT	MINERAL	d SPACING (Å)	REL. INT. (I/I_o)
	Kaolinite	6.70	100
		3.63	77
		4.39	34
	Quartz	3.29	100
		4.17	35
		1.81	17
Seal Beach No. 1	Apophylite	3.95	100
		2.93	80
		1.54	80
	Aragonite	3.46	100
		3.18	52
	Calcite	3.15	100
		2.11	18
	Kaolinite	6.80	100
		3.63	77
	Quartz	3.29	100
		4.11	35
		1.80	17
Seal Beach No. 2	Aragonite	3.48	100
		3.21	52
	Calcite	3.14	100
		2.26	18
		2.10	18
	Quartz	3.30	100
		4.17	35
		1.81	17
Elkhorn No. 1	Calcite	3.15	100
		2.25	18
		2.12	18

SEDIMENT	MINERAL	d SPACING (Å)	REL. INT. (I/I_o)
	Quartz	3.30	100
		4.17	35
		1.81	17
Elkhorn No. 2	Calcite	3.15	100
		2.25	18
		2.13	18
	Apophylite	3.90	100
		2.93	80
		1.66	80
	Quartz	3.30	100
		4.19	35
		1.77	17
Monterey Canyon	Calcite	3.15	100
		2.26	18
		2.12	18
	Quartz	3.31	100
		4.13	35
		1.80	17
Buoy B	Aragonite	3.40	100
		1.97	65
		3.24	52
	Calcite	3.13	100
		2.25	18
		2.15	18

Table 4. Analysis of X-ray Diffractograms

Degrees -2θ readings to equivalent d-spacing values by using a computerized print out.

As mentioned above, a significant clay fraction was identified in two of the samples. The non-plastic clay identified, kaolinite, is known to exist in the Seal Beach area. It is not unlikely that plastic clays may also exist in the Seal Beach samples and in the Monterey Canyon sample. Possible identification of these clay constituents was undoubtedly hampered by the presence of dominant minerals and the organic carbon and carbonate carbon fractions. Even if the most elaborate sample preparations are used, identification of montmorillonite and illite, the most commonly found plastic marine clays, is difficult due to the comparatively weak peak intensities given on the diffractogram.

Worthy of mention was the fact that the minerals quartz and calcite were found in all of the samples studied. This is not surprising since these two minerals are very common in sediments of terriginous origin. The presence of aragonite in three of the samples was probably the result of the decomposition of marine shells. In conclusion Seal Beach No. 1 and 2 are probably of true clay mineral composition while the Monterey Canyon sample contains primarily clay sized clastic mineral components.

IV. CONCLUSION

It is possible to draw several conclusions from this study. Based on the findings of this study, it is concluded that temperatures in the range from 130 to 150°C are equally as acceptable as the standard drying temperature of 110 ± 5°C. The advantage of using a higher temperature is that an appreciable amount of time can be saved. It appears that temperatures in excess of 150°C do not appreciably further reduce the drying time. In drying sediments containing appreciable quantities of organic matter a temperature less than the boiling point of pure water should be used. This investigation confirms that there is no necessity toward using a temperature of 110°C for the drying of marine sediments in order to secure satisfactory results with inorganic sediments.

The water content of a marine sediment appears to vary depending on the drying temperature used. Perhaps the dissolved salt content plays an important role in controlling the water content of sediments. It is suspected that this interrelationship may be especially true for the fine grained, highly plastic sediments such as montmorillonite. Additionally, the water content of a given sample appears to decrease with an increase in sample weight. Perhaps this also is related to the dissolved salt content.

The concept of a normalized water content proved to be a valuable aid in arriving at an elapsed time for a given drying temperature.

This concept is also useful in showing the relationship between sample weight and drying time for any one drying temperature. If the general nature of a sediment is known, appreciable time can be saved in the drying process by consulting the family of curves presented as to the relationship between normalized water content, sample weight and elapsed time.

The drying of sediments consisting primarily of plastic clays should be further investigated since it is known that such sediments (soils) break down at a relatively low temperature. If drying temperatures approaching the upper limit of the temperature range considered in this study were used in drying these clays, a greatly misleading value of water content may be subsequently reported. Sediments containing mostly montmorillonite, for example, should be dried with caution if using drying temperatures exceeding 150°C.

V. SUGGESTED AREAS FOR FUTURE RESEARCH

A fruitful portion of any noteworthy research endeavor is the recommendation of areas for future investigation. The following thoughts are interjected with the hope of providing the stimulus for future research projects.

A. DIFFERENTIAL THERMAL ANALYSIS

Differential thermal analyses (DTA) were not made on the samples studied for reasons of non-availability of the necessary equipment. DTA has two distinct applications in the field of marine sedimentology. Of primary interest, perhaps, is its use in determining the yield or ignition point of sediment samples. While sediments high in organic content have a low yield point (usually around 100°C) the non-plastic clays such as kaolinite have relatively high yield points (about 600°C) (Huber 1955). In conducting water content studies at temperatures in excess of 100°C it would be advantageous to know at what temperature the component structure begins to break down. This temperature would be available from DTA records. DTA is also of aid in the identification of the clay constituents. As was the case for spectrographic analysis, each mineral yields a unique trace. DTA, therefore, could be used in conjunction with X-ray diffraction to identify and classify the fine grained sediments of Monterey Bay.

B. CONTINUATION OF WATER CONTENT STUDIES

The study conducted here represents an area where continued investigation should be profitable. It would be advantageous to concentrate such a study on the finer grained sediments, particularly sediments containing a high percentage of true clay particles. The true clay sediments will likely take longer to dry than ones of higher clastic content. Careful attention should be devoted to the sub-sampling techniques in order to insure that representative materials are tested. Useful results concerning the water content-sample weight relationship could possibly be obtained by considering four distinct sub-sample weight groups of 10, 20, 30, and 40 grams. Sediments containing large amounts of organic matter should be studied in detail.

C. X-RAY DIFFRACTION

A joint study of the sediments of Monterey Bay as to water content and sediment structure would likely prove valuable toward better understanding the role that soluable salts play in controlling the water content of marine sediments. Methods of sample preparation should be exhausted in an effort to improve on the difficult task of identifying many of the highly plastic clays such as montmorillonite.

TABLE A

Project: Water Content Study | Sediment: *Seal Beach #1 & 2* | Date: *4/21/69*

Drying Temperature: *90 °C* | Sample No.: *8 & 8* | Time: *0830*

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		34.538	W.C. N.W.	48.482		41.603		57.986		32.721		34.848		59.402		53.620	
Weigh. No.	Time (Hrs)																
1	1020 (2.0)	24.760		35.850	68 72	30.910	73 77	45.310		22.490		29.020	58 45	48.630		43.540	50 48
2	1130 (3.0)	23.870		33.030	82 87	28.940	88 92	41.390		21.670		27.190	77 60	44.240		39.720	65 63
3	1230 (4.0)	23.560		31.660	90 96	28.080	94 99	38.500		21.450		26.340	86 67	40.850		37.370	79 77
4	1330 (5.0)	23.490		30.940	93 99	27.680	96 101	36.990		21.370		25.860	91 71	38.550		35.930	85 84
5	1430 (6.0)	23.450		30.420	96 102	27.430	98 103	36.010		21.350		25.540	93 73	37.050		34.940	92 89
6	1530 (7.0)	23.439		30.130	98 104	27.290	99 104	35.390		21.223		25.310	96 75	35.960		34.230	95 92
7	1630 (8.0)	23.430		29.970	99 105	27.210	99 104	35.050		21.335		25.210	96 75	35.400		33.830	97 94
8	1730 (9.0)	23.431		29.870	100 106	27.160	100 105	34.810		21.325		25.120	98 76	34.920		33.500	98 95
9	0800 (23.5)	23.414		29.707	100 106	27.067	100 105	34.442		21.321		24.937	100 78	34.201		33.024	100 97
② Wt. Dish + Dry Sed.		23.430		29.707		27.067		34.442		21.325		24.937		34.201		33.024	
③ Wt. of Dish		12.059		11.986		12.263		12.119		11.997		12.221		11.995		11.883	
④ Wt. of Water, ①−②		11.108		18.675		14.536		23.544		11.400		9.910		25.201		20.596	
⑤ Wt. of Dry Sed, ②−③		11.371		17.621		13.807		22.323		9.328		12.716		22.206		21.141	
⑥ Water Content, ④/⑤		97.9		105.8		105.2		105.3		122.4		78.0		113.4		97.5	

TABLE B

Project: Water Content Study Sediment: Elkhorn #1 & 2 Date: 7/9/69

Drying Temperature: 90° C Sample No.: 9 & 9 Time: 0835

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		44.645	W.C. / N.W.	38.078		54.739		44.502		38.578		42.489		49.867		49.216	
Weigh. No.	Time (Hrs)																
1	0935 (1.0)	38.920		32.860	54 / 31	49.730	32 / 18	39.680		31.720	43 / 65	36.700		44.140	25 / 39	44.140	
2	1035 (2.0)	35.430		29.540	90 / 51	45.440	60 / 34	35.640		26.310	76 / 116	31.330		38.600	49 / 77	39.110	
3	1235 (4.0)	32.700		28.590	100 / 57	40.360	94 / 53	32.460		23.070	97 / 148	26.430		30.090	85 / 135	31.210	
4	1335 (5.0)	32.663		28.583	100 / 57	39.500	99 / 56	32.434		22.660	99 / 152	25.570		28.440	92 / 145	29.550	
5	1435 (6.0)	32.659		28.581	100 / 57	39.417	100 / 56	32.430		22.520	99+ / 153	25.160		27.490	96 / 152	28.400	
6	1535 (7.0)	32.656		28.580	100 / 57	39.405	100 / 56	32.426		22.475	99+ / 153	24.997		26.990	99 / 156	27.740	
7	1635 (8.0)	32.656		28.580	100 / 57	39.403	100 / 56	32.426		22.456	100 / 153	24.940		26.803	99+ / 157	27.445	
8	1735 (9.0)	32.656		28.580	100 / 57	39.403	100 / 56	32.427		22.450	100 / 153	24.917		26.735	99+ / 157	27.333	
9	0900 (24.5)	32.648		28.575	100 / 57	39.391	100 / 56	32.421		22.432	100 / 153	24.879		26.644	100 / 158	27.213	
② Wt. Dish + Dry Sed.		32.656		28.580		39.403		32.426		22.432		24.879		26.644		27.213	
③ Wt. of Dish		12.054		11.980		12.259		12.114		11.991		12.217		11.990		11.878	
④ Wt. of Water, ①−②		11.989		9.498		15.336		12.075		16.146		17.610		23.223		22.003	
⑤ Wt. of Dry Sed, ②−③		20.602		16.600		27.144		20.312		10.541		12.662		14.654		15.335	
⑥ Water Content, ④/⑤		58.1		57.2		56.6		59.4		153.0		139.0		158.2		143.7	

TABLE C

Project: Water Content Study   Sediment: Monterey Canyon & Buoy B   Date: 7/28/69

Drying Temperature: 90° C   Sample No.: 9 & 9   Time: 0825

Weigh. No.	Time (Hrs)	Dish 1	W.C. / N.W.	Dish 2	Dish 3	Dish 4	W.C. / N.W.	Dish 5	Dish 6	W.C. / N.W.	Dish 7	W.C. / N.W.	Dish 8
① Wt. Dish + Wet Sed. →		41.829		37.899	34.144	49.163		42.608	41.652		51.916		41.678
1	0925 (1.0)	36.340	31 / 46	31.710	29.000	44.980	22 / 23	36.190	35.780	70 / 30	46.350	44 / 20	36.900
2	1025 (2.0)	31.000	61 / 90	26.820	24.350	40.820	44 / 46	33.650	32.930	98 / 42	42.280	76 / 35	33.290
3	1225 (4.0)	25.640	91 / 135	23.460	21.490	33.950	81 / 84	33.590	32.790	100 / 43	39.350	100 / 46	32.520
4	1325 (5.0)	24.630	97 / 143	22.880	21.310	32.250	91 / 94	33.587	32.786	100 / 43	39.348	100 / 46	32.519
5	1425 (6.0)	24.210	99 / 147	22.740	21.306	31.190	95 / 99	33.587	32.787	100 / 43	39.348	100 / 46	32.520
6	1525 (7.0)	24.100	100 / 148	22.690	21.283	30.570	99 / 103	33.583	32.783	100 / 43	39.342	100 / 46	32.517
7	1625 (8.0)	24.071	100 / 148	22.676	21.282	30.310	99+ / 104	33.583	32.782	100 / 43	39.341	100 / 46	32.516
8	1725 (9.0)	24.067	100 / 148	22.676	21.283	30.260	99+ / 104	33.584	32.783	100 / 43	39.342	100 / 46	32.517
9	1125 (27.0)	24.051	100 / 148	22.665	21.276	30.217	100 / 105	33.578	32.777	100 / 43	39.333	100 / 46	32.510
② Wt. Dish + Dry Sed.		24.051		22.665	21.276	30.217		33.583	32.783		39.342		32.517
③ Wt. of Dish		12.053		11.980	12.258	12.112		11.990	12.215		11.989		11.877
④ Wt. of Water, ①−②		17.778		15.234	12.868	18.946		9.025	8.869		12.574		9.161
⑤ Wt. of Dry Sed, ②−③		11.998		10.685	9.018	18.105		21.593	20.568		27.353		20.640
⑥ Water Content, ④/⑤		148.0		142.6	142.8	104.7		41.8	43.2		45.9		44.4

TABLE D

Project: Water Content Study

Sediment: Monterey Canyon

Date: 7/31/69

Drying Temperature: 90° C

Sample No.: 10

Time: 0840

Dish Number		1		2		3		4		5		6		7		8	
①Wt. Dish+Wet Sed. →			W.C.														
Weigh. No.	Time (Hrs)	49.893	N.W.	50.286													
1	1440 (6.0)	27.000		29.305													
2	1440 (30.0)	26.944		29.196													
②Wt. Dish+Dry Sed.		26.944		29.196													
③Wt. of Dish		12.052		11.980													
④Wt. of Water, ①−②		22.749		21.090													
⑤Wt. of Dry Sed, ②−③		14.892		21.090													
⑥Water Content, ④/⑤		152.8		122.5													

TABLE E

Project: Water Content Study

Drying Temperature: 100 °C

Sediment: Seal Beach #1 & 2

Sample No.: 9 & 9

Date: 7/14/69

Time: 0815

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →																	
Weigh. No.	Time (Hrs)	51.601	W.C. N.W.	48.664		42.233		41.057		48.976		58.881		38.006		40.700	
1	0915 (1.0)	45.060		42.640	33 33	36.400		36.220	31 36	41.530	38 39	51.660		32 150		35.090	40 40
2	1015 (2.0)	38.980		37.120	64 63	31.760		31.420	63 72	35.040	73 74	44.910		27.940		30.240	73 73
3	1215 (4.0)	33.870		31.880	92 91	28.560		26.750	93 107	30.250	97 99	37.590		25.090		26.680	97 97
4	1515 (7.0)	32.857		30.513	99 98	27.660		25.660	99 114	29.752	99+ 102	35.440		24.462		26.319	99+ 100
5	1615 (8.0)	32.801		30.445	99+ 99	27.586		25.613	99 114	29.747	100 102	35.330		24.438		26.311	100 100
6	1715 (9.0)	32.773		30.415	99+ 99+	27.543		25.593	100 115	29.744	100 102	35.280		24.428		26.308	100 100
7	0815 (24.0)	32.721		30.365	100 99+	27.453		25.556	100 115	29.732	100 102	35.203		24.407		26.295	100 100

	1	2	3	4	5	6	7	8
② Wt. Dish + Dry Sed.	32.721	30.365	27.453	25.556	29.732	35.203	24.407	26.295
③ Wt. of Dish	12.054	11.981	12.259	12.114	11.992	12.217	11.990	11.878
④ Wt. of Water, ①−②	18.880	18.299	14.780	15.501	19.244	23.678	13.599	14.405
⑤ Wt. of Dry Sed. ②−③	20.667	18.384	15.193	13.442	18.840	22.986	13.417	14.417
⑥ Water Content, ④/⑤	91.3	99.6	97.4	115.2	102.2	103.1	101.2	99.9

TABLE F

Project: Water Content Study | Sediment: Elkhorn #1 & 2 | Date: 7/8/69

Drying Temperature: 100° C | Sample No.: 8 & 8 | Time: 0825

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		45.160	W.C. N.W.	46.119		36.457		61.799		52.867		34.688		47.403		36.762	
Weigh. No.	Time (Hrs)																
1	0925 (1.0)	38.300		39.340	54 32	30.640	65 39	56.620		44.840		27.290		40.910	30 45	30.960	38 59
2	1025 (2.0)	33.950		35.100	88 52	27.780	96 58	51.720		37.390		22.850		35.020	59 87	25.680	74 114
3	1125 (3.0)	32.350		33.500	99+ 59	27.270	100 61	47.910		32.840		21.420		30.470	80 119	22.680	93 144
4	1425 (6.0)	32.303		33.452	100 59	27.260	100 61	43.766		28.451		20.838		26.339	99 147	21.680	100 154
5	1525 (7.0)	32.303		33.452	100 59	27.260	100 61	43.763		28.399		20.834		26.275	99+ 148	21.678	100 154
6	1625 (8.0)	32.302		33.451	100 59	27.259	100 61	43.761		28.383		20.833		26.256	99+ 148	21.678	100 154
7	1725 (9.0)	32.301		33.449	100 59	27.258	100 61	43.759		28.376		20.831		26.245	100 148	21.676	100 154
8	0810 (23.8)	32.293		33.441	100 59	27.252	100 61	43.744		28.352		20.820		26.221	100 148	21.666	100 154

	1	2	3	4	5	6	7	8
② Wt. Dish + Dry Sed.	32.303	33.452	27.260	43.759	28.376	20.831	26.245	21.678
③ Wt. of Dish	12.055	11.981	12.261	12.115	11.994	12.219	11.991	11.879
④ Wt. of Water, ①-②	12.867	12.678	9.197	18.050	24.491	13.868	21.182	15.096
⑤ Wt. of Dry Sed., ②-③	20.248	21.371	14.999	31.644	16.382	8.612	14.254	9.799
⑥ Water Content, ④/⑤	63.7	59.5	61.2	57.0	149.0	161.0	148.5	154.0

TABLE G

Project: Water Content Study		Sediment: Monterey Canyon & Buoy B										Date: 7/25/69					
Drying Temperature: 100° C		Sample No.: 8 & 8										Time: 0815					
Dish Number		1		2		3		4		5		6		7		8	
①Wt. Dish+Wet Sed. →		31.939	W.C. N.W.	38.853		47.521		43.386		43.094		41.656		46.152		51.320	
Weigh. No.	Time (Hrs)																
1	0915 (1.0)	25.410		32.450	36 53	41.950	26 39	39.290		36.180		35.000	73 33	40.400		46.640	39 17
2	1015 (2.0)	21.040		26.600	76 113	36.330	53 79	34.840		33.790		32.530	98 44	36.490		42.170	77 34
3	1115 (3.0)	19.820		23.710	95 140	31.650	76 112	30.990		33.780		32.520	100 45	35.900		39.450	98 43
4	1215 (4.0)	19.760		22.880	99 147	28.480	91 134	28.150		33.775		32.517	100 45	35.896		39.260	100 44
5	1315 (5.0)	19.759		22.825	100 148	27.000	98 145	26.510		33.773		32.514	100 45	35.893		39.258	100 44
6	1415 (6.0)	19.760		22.823	100 148	26.530	99+ 147	26.000		33.774		32.514	100 45	35.894		39.256	100 44
7	1615 (8.0)	19.757		22.819	100 148	26.458	100 148	25.950		33.774		32.515	100 45	35.894		39.255	100 44
8	1715 (9.0)	19.757		22.818	100 148	26.455	100 148	25.948		33.774		32.515	100 45	35.893		39.255	100 44
9	1315 (29.0)	19.754		22.813	100 148	26.444	100 148	25.938		33.770		32.510	100 45	35.887		39.248	100 44
②Wt. Dish + Dry Sed.		19.757		22.818		26.455		25.948		33.774		32.514		35.894		39.255	
③Wt. of Dish		12.052		11.979		12.258		12.112		11.990		12.215		11.988		11.876	
④Wt. of Water, ①−②		12.182		16.035		21.066		17.438		9.320		9.142		10.258		12.065	
⑤Wt. of Dry Sed, ②−③		7.707		10.839		14.197		13.836		21.774		20.299		23.906		27.379	
⑥Water Content, ④/⑤		158.0		147.8		148.5		126.1		42.8		45.0		42.9		44.1	

TABLE H

Project: Water Content Study | Sediment: *Seal Beach #1 & 2* | Date: *4/16/69*

Drying Temperature: *110° C* | Sample No.: *6 & 6* | Time: *0815*

Dish Number		1	W.C. N.W.	2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		60.316		33.977		42.881		54.480		51.114		36.746		31.980		41.955	
Weigh. No.	Time (Hrs)																
1	1020 (2.0)	43.790		22.840		29.250	85 94	40.230	70 69	36.710	77 72	25.700		21.320		29.910	77 82
2	1115 (3.0)	40.450		22.400		27.370	95 107	36.820	84 83	34.570	88 83	24.660		21.060		28.040	90 95
3	1215 (4.0)	38.580		22.361		26.840	99 110	34.820	94 93	33.210	95 89	24.318		21.010		27.050	98 102
4	1315 (5.0)	37.560		22.355		26.794	100 111	33.885	98 97	32.580	98 93	24.245		21.010		26.736	99 104
5	1415 (6.0)	37.167		22.353		26.789	100 111	33.494	99 98	32.291	99+ 94	24.228		21.009		26.628	100 104
6	1515 (7.0)	37.025		22.352		26.783	100 111	33.403	99+ 99	32.201	99+ 94	24.225		21.002		26.586	100 104
7	1615 (8.0)	36.950		22.350		26.781	100 111	33.382	100 99	32.156	99+ 94	24.223		21.006		26.576	100 104
8	1715 (9.0)	36.921		22.350		26.780	100 111	33.366	100 99	32.130	99+ 94	24.221		20.995		26.562	100 104
9	0745 (23.5)	36.871		22.341		26.763	100 111	33.351	100 99	32.124	100 94	24.210		20.990		26.552	100 104
② Wt. Dish + Dry Sed.		36.871		22.350		26.780		33.366		32.111		24.221		20.995		26.562	
③ Wt. of Dish		12.058		11.985		12.263		12.119		11.996		12.221		11.994		11.882	
④ Wt. of Water, ①−②		23.441		11.627		16.101		21.114		18.986		12.523		10.985		15.393	
⑤ Wt. of Dry Sed, ②−③		24.813		20.365		14.517		21.247		20.134		12.000		9.001		14.680	
⑥ Water Content, ④/⑤		94.5		112.3		111.0		99.3		94.4		104.3		122.0		104.8	

TABLE I

Project: Water Content Study **Sediment:** Elkhorn #1 & 2 **Date:** 4/22/69

Drying Temperature: 110° C **Sample No.:** 1 & 1 **Time:** 0830

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		58.826	W.C./N.W.	30.638		34.667		57.362		41.124		42.195		50.488		32.108	
Weigh. No.	Time (Hrs)																
1	1030 (2.0)	45.260		22.380		24.400	99/85	43.030	76/57	27.530	77/118	26.380		35.480	66/96	20.440	
2	1230 (4.0)	39.070		22.374		24.385	100/85	37.970	99+/75	23.560	99/152	24.010		28.240	97/142	20.060	
3	1330 (5.0)	39.005		22.372		24.380	100/85	37.960	99+/75	23.510	100/153	24.001		27.670	99/145	20.056	
4	1430 (6.0)	38.988		22.371		24.378	100/85	37.955	100/75	23.510	100/153	23.995		27.631	99+/146	20.054	
5	1530 (7.0)	38.986		22.371		24.378	100/85	37.954	100/75	23.509	100/153	23.995		27.611	100/146	20.053	
6	1730 (9.0)	38.977		22.370		24.376	100/85	37.954	100/75	23.509	100/153	23.996		27.611	100/146	20.053	
② Wt. Dish + Dry Sed.		38.986		22.371		24.378		37.955		23.510		23.995		27.611		20.054	
③ Wt. of Dish		12.057		11.984		12.263		12.118		11.995		12.220		11.992		11.881	
④ Wt. of Water, ①−②		19.840		8.267		10.289		19.415		17.614		18.200		22.877		12.058	
⑤ Wt. of Dry Sed, ②−③		26.929		10.387		12.115		25.837		11.515		11.795		15.618		8.173	
⑥ Water Content, ④/⑤		73.8		79.7		84.6		75.3		153.0		154.5		146.2		147.3	

TABLE J

Project: Water Content Study

Sediment: Monterey Canyon & Buoy B

Date: 7/16/69

Drying Temperature: 110° C

Sample No.: 3 & 3

Time: 0800

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		46.353	W.C. / N.W.	35.408		40.005		42.835		40.662		63.058		58.711		48.965	
Weigh. No.	Time (Hrs)																
1	0900 (1.0)	38.000	38 / 66	27.520		33.600	38 / 59	37.420		32.670	85 / 41	54.930		51.060		42.580	30 / 14
2	1000 (2.0)	31.070	69 / 121	23.030		27.830	78 / 122	32.620		31.330	99+ / 48	49.030		45.880		38.170	91 / 42
3	1100 (3.0)	27.230	86 / 151	21.230		24.550	92 / 143	29.200		31.327	100 / 48	47.420		44.860		37.350	99+ / 45+
4	1300 (5.0)	24.700	99 / 174	20.690		23.120	99+ / 156	26.520		31.325	100 / 48	47.416		44.851		37.343	100 / 46
5	1400 (6.0)	24.656	99+ / 175	20.685		23.106	100 / 156	26.410		31.324	100 / 48	47.414		44.848		37.341	100 / 46
6	1500 (7.0)	24.647	100 / 175	20.683		23.102	100 / 156	26.393		31.324	100 / 48	47.412		44.847		37.340	100 / 46
7	1600 (8.0)	24.645	100 / 175	20.682		23.100	100 / 156	26.389		31.323	100 / 48	47.411		44.846		37.340	100 / 46
8	1700 (9.0)	24.643	100 / 175	20.680		23.099	100 / 156	26.387		31.322	100 / 48	47.410		44.845		37.339	100 / 46
9	0745 (23.8)	24.628	100 / 175	20.670		23.087	100 / 156	26.372		31.316	100 / 48	47.400		44.834		37.330	100 / 46
② Wt. Dish + Dry Sed.		24.643		20.680		23.099		26.387		31.322		47.410		44.845		37.339	
③ Wt. of Dish		12.054		11.981		12.260		12.114		11.992		12.216		11.990		11.877	
④ Wt. of Water, ① − ②		21.710		14.728		16.906		16.258		9.340		15.648		13.876		11.626	
⑤ Wt. of Dry Sed, ② − ③		12.589		8.699		10.839		14.273		19.330		35.194		32.855		25.462	
⑥ Water Content, ④/⑤		175.2		169.6		156.2		114.0		48.2		44.5		42.2		45.7	

TABLE K

Project: Water Content Study		Sediment: Seal Beach #1 & 2		Date: 4/7/69
Drying Temperature: 120° C		Sample No.: 2 & 2		Time: 1128

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		51.398	W.C. N.W.	38.587		40.144		53.053		63.080		43.560		49.453		53.998	
Weigh. No.	Time (Hrs)																
1	1228 (1.0)	51.980		29.280		32.650	55 53	45.880	35 35	53.650		35.310	46 60	39.620	50 55	47.040	
2	1328 (2.0)	44.770		26.000		27.900	90 87	38.070	73 74	46.230		28.690	83 110	34.420	77 83	38.920	
3	1428 (3.0)	40.720		25.370		26.580	99 97	34.380	92 93	42.180		26.480	[illegible] 127	3[illegible].570	93 100	34.740	
4	1528 (4.0)	38.281		25.286		26.426	100 97	32.932	98 99	39.530		25.832	99 131	30.430	98 106	32.595	
5	1628 (5.0)	37.010		25.272		26.416	100 97	32.560	99 100	37.967		25.748	100 132	30.087	99 108	31.617	
6	1728 (6.0)	36.730		25.260		26.407	100 97	32.507	99+ 101	37.473		25.736	100 132	30.018	99+ 108	31.432	
7	0828 (21.0)	36.610		25.254		26.393	100 97	32.477	100 101	37.280		25.725	100 132	29.966	100 108	31.365	
② Wt. Dish + Dry Sed.		36.610		25.254		26.393		32.477		37.280		25.725		29.966		31.365	
③ Wt. of Dish		12.061		11.988		12.265		12.122		11.998		12.224		11.997		11.885	
④ Wt. of Water, ① − ②		24.788		13.333		13.751		20.576		25.800		17.845		19.487		22.633	
⑤ Wt. of Dry Sed, ② − ③		24.549		13.266		14.128		20.355		25.282		13.501		17.969		19.480	
⑥ Water Content, ④/⑤		101.0		100.5		97.4		101.2		102.1		132.2		108.5		116.5	

TABLE L

Project: Water Content Study   Sediment: Elkhorn #1 & 2   Date: 5/6/69

Drying Temperature: 120° C   Sample No.: 7 & 7   Time: 0830

Dish Number		1		2		3		4		5		6		7		8	
①Wt. Dish+Wet Sed. →		49.070	W.C. N.W.	45.293		60.760		35.456		52.357		53.156		42.049		37.212	
Weigh. No.	Time (Hrs)																
1	1030 (2.0)	35.780	99+ 56	32.200		45.790		26.410	99 63	33.230	83 111	33.760		25.870	92 130	23.920	
2	1230 (4.0)	35.736	100 56	32.174		44.413		26.408	100 63	29.351	99+ 134	28.820		24.460	100 141	22.150	
3	1330 (5.0)	35.736	100 56	32.174		44.413		26.406	100 63	29.251	100 134	28.787		24.455	100 141	22.142	
4	1430 (6.0)	35.736	100 56	32.174		44.411		26.406	100 63	29.251	100 134	28.784		24.454	100 141	22.141	
5	1530 (7.0)	35.734	100 56	32.173		44.411		26.405	100 63	29.249	100 134	28.784		24.455	100 141	22.141	
6	1630 (8.0)	35.734	100 56	32.173		44.411		26.405	100 63	29.249	100 134	28.783		24.454	100 141	22.141	
②Wt. Dish + Dry Sed.		35.736		32.174		44.411		26.406		29.251		28.784		24.454		22.141	
③Wt. of Dish		12.056		11.982		12.261		12.115		11.993		12.219		11.992		11.879	
④Wt. of Water, ①−②		13.334		13.119		16.349		9.050		23.107		24.372		17.595		15.071	
⑤Wt. of Dry Sed, ②−③		23.680		20.192		32.150		14.291		17.248		16.565		12.462		10.262	
⑥Water Content, ④/⑤		56.4		60.0		50.9		63.4		134.0		147.0		141.2		147.0	

TABLE M

Project: Water Content Study | Sediment: Monterey Canyon & Buoy B | Date: 7/18/69

Drying Temperature: 120° C | Sample No.: 5 & 5 | Time: 0810

Dish Number		1		2		3		4		5		6		7		8	
①Wt. Dish+Wet Sed. →		39.359	W.C. N.W.	40.719		35.866		60.746		46.978		46.188		40.962		42.129	
Weigh. No.	Time (Hrs)																
1	0910 (1.0)	30.500		30.940	59/81	26.960		53.600	24/38	37.650	86/38	36.770		32.410	79/45	35.030	
2	1010 (2.0)	25.580		25.300	92/127	21.830		46.620	47/75	36.370	99+/44	35.440		31.020	100/52	32.690	
3	1210 (4.0)	23.475		24.070	100/138	21.225		35.490	85/134	36.361	100/44	35.430		31.022	100/52	32.683	
4	1310 (5.0)	23.471		24.070	100/138	21.226		32.780	94/149	36.363	100/44	35.432		31.024	100/52	32.685	
5	1410 (6.0)	23.469		24.069	100/138	21.224		31.220	99/157	36.361	100/44	35.430		31.021	100/52	32.682	
6	1510 (7.0)	23.467		24.067	100/138	21.223		30.945	99+/158	36.360	100/44	35.430		31.021	100/52	32.681	
7	1610 (8.0)	23.465		24.065	100/138	21.221		30.918	100/159	36.358	100/44	35.428		31.020	100/52	32.680	
8	1710 (9.0)	23.466		24.066	100/138	21.222		30.912	100/159	36.358	100/44	35.427		31.020	100/52	32.680	
②Wt. Dish+Dry Sed.		23.465		24.065		21.221		30.912		36.361		35.430		31.021		32.682	
③Wt. of Dish		12.053		11.980		12.259		12.113		11.991		12.216		11.989		11.877	
④Wt. of Water, ①–②		15.894		16.654		14.644		29.832		10.617		10.761		9.942		9.449	
⑤Wt. of Dry Sed. ②–③		11.412		12.085		8.962		18.799		24.370		23.214		19.032		20.805	
⑥Water Content, ④/⑤		139.2		138.0		163.5		158.8		43.7		46.3		52.3		45.7	

TABLE N

Project: Water Content Study | Sediment: Seal Beach #1 & 2 | Date: 4/15/69

Drying Temperature: 130° C | Sample No.: 5 & 5 | Time: 0835

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		40.550	W.C. / N.W.	74.334		48.779		70.960		48.711		69.090		45.337		41.089	
Weigh. No.	Time (Hrs)																
1	1035 (2.0)	24.670	98 / 129	56.960		31.050	89 / 108	54.250		32.930	80 / 94	53.730		30.190		28.160	86 / 91
2	1235 (4.0)	24.380	100 / 132	45.140		28.730	99+ / 122	41.090		28.920	99+ / 117	43.320		27.940		26.090	99 / 105
3	1435 (6.0)	24.377	100 / 132	44.160		28.721	100 / 122	39.859		28.903	100 / 117	41.123		27.931		26.063	100 / 106
4	1535 (7.0)	24.377	100 / 132	44.146		28.721	100 / 122	39.847		28.903	100 / 117	41.097		27.931		26.063	100 / 106
5	1635 (8.0)	24.377	100 / 132	44.145		28.720	100 / 122	39.846		28.902	100 / 117	41.096		27.931		26.064	100 / 106
② Wt. Dish + Dry Sed.		24.377		44.146		28.721		39.847		28.903		41.097		27.931		26.063	
③ Wt. of Dish		12.059		11.985		12.264		12.119		11.996		12.221		11.995		11.882	
④ Wt. of Water, ①−②		16.173		30.188		20.058		31.113		19.808		27.993		17.342		15.026	
⑤ Wt. of Dry Sed, ②−③		12.318		32.161		16.457		27.728		16.907		28.876		15.936		14.181	
⑥ Water Content, ④/⑤		131.0		93.8		122.0		112.2		117.1		97.0		108.9		106.1	

TABLE O

Project: Water Content Study — Sediment: Elkhorn #1 & 2 — Date: 5/5/69

Drying Temperature: 130° C — Sample No.: 6 & 6 — Time: 1125

Dish Number		1	W.C. / N.W.	2	W.C. / N.W.	3	W.C. / N.W.	4	W.C. / N.W.	5	W.C. / N.W.	6	W.C. / N.W.	7	W.C. / N.W.	8	W.C. / N.W.
① Wt. Dish + Wet Sed. →		52.687		50.954		42.077		38.040		61.270		32.817		57.077		36.984	
Weigh. No.	Time (Hrs)																
1	1225 (1.0)	42.070		40.250	81 / 42	32.560		29.520	88 / 52	49.820		23.350		47.380	39 / 48	28.500	58 / 79
2	1325 (2.0)	37.320		37.660	99+ / 52	30.720		28.480	99 / 59	41.280		21.090		39.510	71 / 86	23.410	93 / 126
3	1525 (4.0)	37.295		37.649	100 / 52	30.707		28.471	100 / 59	34.738		20.986		32.432	98 / 120	22.578	100 / 135
4	1625 (5.0)	37.291		37.646	100 / 52	30.705		28.468	100 / 59	34.710		20.983		32.276	99 / 122	22.574	100 / 135
5	1725 (6.0)	37.288		37.643	100 / 52	30.702		28.465	100 / 59	34.700		20.979		32.257	99+ / 122	22.570	100 / 135
6	0800 (20.5)	37.280		37.636	100 / 52	30.698		28.463	100 / 59	34.690		20.979		32.243	100 / 122	22.567	100 / 135
② Wt. Dish + Dry Sed.		37.288		37.643		30.702		28.465		34.700		20.979		32.257		22.570	
③ Wt. of Dish		12.055		11.983		12.261		12.115		11.993		12.219		11.992		11.879	
④ Wt. of Water, ① − ②		15.399		13.321		11.375		9.575		26.570		11.838		24.820		14.414	
⑤ Wt. of Dry Sed., ② − ③		25.233		25.660		18.441		16.350		22.707		8.780		20.265		10.691	
⑥ Water Content, ④/⑤		61.0		51.9		61.6		58.6		117.0		135.0		122.3		134.9	

TABLE P

Project: Water Content Study — Sediment: Monterey Canyon & Buoy B — Date: 7/11/69

Drying Temperature: 130° C — Sample No.: 1 & 1 — Time: 0815

Dish	Number	1		2		3		4		5		6		7		8	
①Wt. Dish+Wet Sed. →		42.536	W.C. N.W.	39.287		52.799		37.212		40.746		52.109		66.950		53.757	
Weigh. No.	Time (Hrs)																
1	0915 (1.0)	32.120		29.140	63/91	41.090	50/69	28.630		32.020	99+/44	41.890	83/38	57.840		45.500	
2	1015 (2.0)	24.510		24.450	92/133	32.400	86/120	23.320		31.957	100/44	39.908	100/46	50.550		41.190	
3	1115 (3.0)	23.160		23.160	99/144	29.470	99+/138	22.330		31.954	100/44	39.902	100/46	49.797		41.181	
4	1215 (4.0)	23.152		23.125	100/145	29.255	100/139	22.318		31.954	100/44	39.900	100/46	49.790		41.177	
5	1315 (5.0)	23.150		23.123	100/145	29.251	100/139	22.316		31.954	100/44	39.900	100/46	49.790		41.177	
6	1515 (7.0)	23.146		23.118	100/145	29.245	100/139	22.314		31.954	100/44	39.899	100/46	49.788		41.176	
7	1615 (8.0)	23.147		23.120	100/145	29.245	100/139	22.314		31.951	100/44	39.896	100/46	49.785		41.174	
②Wt. Dish+Dry Sed.		23.146		23.118		29.245		22.314		31.954		39.900		49.790		41.177	
③Wt. of Dish		12.054		11.981		12.259		12.114		11.992		12.217		11.990		11.878	
④Wt. of Water, ①−②		19.390		16.179		23.554		14.898		8.792		12.209		17.160		12.580	
⑤Wt. of Dry Sed, ②−③		11.092		11.137		16.976		10.200		19.962		26.683		37.800		29.299	
⑥Water Content, ④/⑤		175.0		145.1		138.9		146.1		44.2		45.7		45.4		43.0	

TABLE Q

Project: Water Content Study

Sediment: Seal Beach #1 & 2

Date: 4/2/69

Drying Temperature: 140 °C

Sample No.: 1 & 1

Time: 1122

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		39.726	W.C. / N.W.	51.175		42.311		51.073		50.676		52.551		45.529		47.605	
Weigh. No.	Time (Hrs)																
1	1222 (1.0)	30.390	68 / 68	39.010	59 / 64	31.960		38.930		39.980	53 / 57	40.150		36.440	52 / 55	36.340	
2	1322 (2.0)	26.430	98 / 99	32.670	91 / 98	27.260		32.570		33.500	86 / 92	33.100		30.920	85 / 89	31.120	
3	1427 (3.0)	25.809	100 / 101	30.920	99+ / 107	26.834		30.516		30.730	99 / 107	30.564		28.445	99 / 105	29.631	
4	1525 (4.0)	25.801	100 / 101	30.896	100 / 107	26.831		30.486		30.661	100 / 107	30.516		28.362	100 / 105	29.609	
5	1625 (5.0)	25.791	100 / 101	30.890	100 / 107	26.830		30.483		30.661	100 / 107	30.510		28.357	100 / 105	29.592	
6	1725 (6.0)	25.791	100 / 101	30.889	100 / 107	26.830		30.482		30.659	100 / 107	30.500		28.352	100 / 105	29.591	
7	0825 (21.0)	25.790	100 / 101	30.884	100 / 107	26.824		30.477		30.643	100 / 107	30.492		28.346	100 / 105	29.586	
② Wt. Dish + Dry Sed.		25.791		30.890		26.830		30.483		30.661		30.500		28.352		29.592	
③ Wt. of Dish		12.061		11.988		12.266		12.122		12.000		12.225		11.997		11.885	
④ Wt. of Water, ①−②		13.935		20.285		15.481		20.590		20.015		22.051		17.177		18.013	
⑤ Wt. of Dry Sed, ②−③		13.730		18.902		14.564		18.361		18.661		18.275		16.355		17.707	
⑥ Water Content, ④/⑤		101.5		107.5		106.2		112.1		107.5		121.0		105.0		101.8	

TABLE R

Project: Water Content Study

Sediment: Elkhorn #1 & 2

Date: 4/30/69

Drying Temperature: 140° C

Sample No.: 4 & 4

Time: 1125

Dish Number		1	W.C. / N.W.	2		3	4	5		6	7		8
① Wt. Dish + Wet Sed. →		41.144		51.323		52.043	41.822	39.703		44.188	52.264		46.685
Weigh. No.	Time (Hrs)												
1	1225 (1.0)	30.380	98 / 60	41.820	67 / 37	39.640	30.950	28.630	72 / 92	32.320	40.750	49 / 70	35.680
2	1325 (2.0)	30.180	100 / 61	37.400	99+ / 55	36.320	30.100	24.270	99 / 127	26.300	32.390	84 / 120	28.740
3	1425 (3.0)	30.175	100 / 61	37.382	100 / 55	36.310	30.094	24.146	100 / 128	25.400	28.880	99 / 141	27.010
4	1525 (4.0)	30.175	100 / 61	37.380	100 / 55	36.309	30.094	24.142	100 / 128	25.397	28.658	99+ / 141	26.990
5	1625 (5.0)	30.173	100 / 61	37.377	100 / 55	36.306	30.091	24.141	100 / 128	25.395	28.648	100 / 142	26.987
6	1725 (6.0)	30.172	100 / 61	37.376	100 / 55	36.305	30.091	24.139	100 / 128	25.392	28.643	100 / 142	26.983
7	1200 (24.5)	30.164	100 / 61	37.365	100 / 55	36.292	30.082	24.130	100 / 128	25.380	28.625	100 / 142	26.970
② Wt. Dish + Dry Sed.		30.173		37.377		36.306	30.091	24.141		25.395	28.643		26.987
③ Wt. of Dish		12.055		11.983		12.261	12.116	11.993		12.218	11.992		11.879
④ Wt. of Water, ①−②		10.971		13.946		15.737	11.731	15.562		18.793	23.621		19.698
⑤ Wt. of Dry Sed, ②−③		18.118		25.394		24.045	18.975	12.148		13.177	16.651		15.108
⑥ Water Content, ④/⑤		60.4		55.0		65.4	61.9	128.1		142.8	142.0		130.3

TABLE S

Project: Water Content Study | Sediment: Monterey Canyon & Buoy B | Date: 7/17/69

Drying Temperature: 140° C | Sample No.: 4 & 4 | Time: 0810

Dish Number		1		2		3		4		5		6		7		8	
①Wt. Dish + Wet Sed. →		32.644	W.C. N.W.	39.627		46.683		52.412		40.247		49.887		35.876		48.896	
Weigh. No.	Time (Hrs)																
1	0910 (1.0)	21.710		27.690	73 108	34.170		41.790	46 65	31.860	99+ 42	39.050	98 41	28.120		39.520	
2	1010 (2.0)	20.300		23.500	98 145	26.880		33.500	76 106	31.849	100 42	38.705	100 42	28.108		36.645	
3	1210 (4.0)	20.296		23.130	100 148	25.966		29.068	99+ 139+	31.846	100 42	38.699	100 42	28.105		36.636	
4	1510 (6.0)	20.293		23.126	100 148	25.961		29.059	100 140	31.843	100 42	38.696	100 42	28.103		36.633	
5	1610 (7.0)	20.292		23.125	100 148	25.961		29.058	100 140	31.843	100 42	38.695	100 42	28.103		36.632	
②Wt. Dish + Dry Sed.		20.293		23.126		25.961		29.059		31.843		38.696		28.103		36.633	
③Wt. of Dish		12.053		11.980		12.259		12.113		11.991		12.216		11.989		11.877	
④Wt. of Water, ①−②		12.351		16.501		20.722		23.363		8.404		11.181		7.773		12.263	
⑤Wt. of Dry Sed, ②−③		8.240		11.146		13.702		16.946		19.852		26.480		16.114		24.756	
⑥Water Content, ④/⑤		150.1		148.2		151.1		139.7		42.3		42.2		48.2		49.6	

TABLE T

Project: Water Content Study | Sediment: Seal Beach #1 & 2 | Date: 4/8/69

Drying Temperature: 150° C | Sample No.: 3 & 3 | Time: 1230

Dish Number		1	W.C. N.W.	2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		55.032		40.371		44.033		47.322		49.705		65.282		49.267		55.037	
Weigh. No.	Time (Hrs)																
1	1330 (1.0)	42.630		28.300	77 95	33.530		34.900	75 67	38.670	57 61	53.270		36.550	68 69	42.350	
2	1430 (2.0)	35.060		24.700	98 122	28.560		30.940	99 89	32.190	91 97	42.570		31.000	97 99	35.180	
3	1530 (3.0)	33.480		24.672	100 124	28.190		30.685	99+ 90	30.236	99+ 107	37.820		30.447	100 102	33.115	
4	1630 (4.0)	33.455		24.665	100 124	28.188		30.668	100 90	30.193	100 107	37.479		30.427	100 102	33.080	
5	1730 (5.0)	33.455		24.661	100 124	28.177		30.656	100 90	30.190	100 107	37.455		30.424	100 102	33.067	
6	0830 (20.0)	33.432		24.650	100 124	28.166		30.654	100 90	30.179	100 107	37.445		30.412	100 102	33.058	
② Wt. Dish + Dry Sed.		33.455		24.661		28.177		30.656		30.190		37.455		30.427		33.067	
③ Wt. of Dish		12.059		11.986		12.265		12.121		11.997		12.223		11.996		11.883	
④ Wt. of Water, ① − ②		21.577		15.710		15.856		16.666		19.515		27.827		18.837		21.970	
⑤ Wt. of Dry Sed, ② − ③		21.394		12.675		15.912		18.535		18.193		25.232		18.431		21.184	
⑥ Water Content, ④/⑤		100.7		124.1		99.9		90.4		107.4		110.2		102.1		103.9	

TABLE U

Project: Water Content Study | Sediment: Elkhorn #1 & 2 | Date: 4/29/69

Drying Temperature: 150° C | Sample No.: 3 & 3 | Time: 1230

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		36.446	W.C. N.W.	53.533		38.861		59.917		39.790		35.467		49.001		58.606	
Weigh. No.	Time (Hrs)																
1	1330 (1.0)	26.400		40.610	85 49	27.890	99 71	48.690		27.190	80 105	23.700		35.660	60 91	45.790	
2	1430 (2.0)	26.380		38.230	99+ 58	27.720	100 72	42.570		24.060	100 130	21.630		27.870	95 144	36.270	
3	1530 (3.0)	26.370		38.225	100 58	27.717	100 72	42.530		24.048	100 130	21.624		26.710	99+ 152	31.250	
4	1630 (4.0)	26.368		38.223	100 58	27.716	100 72	42.528		24.046	100 130	21.623		26.700	100 152	31.067	
5	1730 (5.0)	26.366		38.221	100 58	27.714	100 72	42.524		24.044	100 130	21.621		26.698	100 152	31.062	
6	0800 (19.5)	26.362		38.210	100 58	27.708	100 72	42.510		24.032	100 130	21.611		26.680	100 152	31.047	
② Wt. Dish + Dry Sed.		26.366		38.221		27.714		42.524		24.044		21.621		26.698		31.062	
③ Wt. of Dish		12.056		11.984		12.262		12.117		11.994		12.219		11.992		11.880	
④ Wt. of Water, ①−②		10.080		15.312		11.147		17.493		15.746		13.846		22.303		27.542	
⑤ Wt. of Dry Sed, ②−③		14.310		26.237		15.452		30.407		12.050		9.402		14.706		19.182	
⑥ Water Content, ④/⑤		70.3		58.4		72.2		57.5		130.8		147.0		151.6		143.7	

TABLE V

Project: Water Content Study — Sediment: Monterey Canyon & Buoy B — Date: 7/15/69

Drying Temperature: 150° C — Sample No.: 2 & 2 — Time: 0830

Dish Number		1	W.C./N.W.	2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		35.112		40.503		37.910		47.830		37.630		56.871		58.220		41.005	
Weigh. No.	Time (Hrs)																
1	0930 (1.0)	24.370		28.140		26.110	88/136	37.270	50/75	29.360		44.540	88/35	46.940		31.740	99+/47
2	1030 (2.0)	20.750		24.410		22.340	100/155	29.280	87/131	29.351		42.715	100/40	44.508		31.655	100/47
3	1130 (3.0)	20.720		24.410		22.332	100/155	26.380	99+/150	29.352		42.714	100/40	44.504		31.655	100/47
4	1330 (5.0)	20.716		24.406		22.328	100/155	26.321	100/151	29.350		42.710	100/40	44.500		31.652	100/47
5	1430 (6.0)	20.715		24.405		22.327	100/155	26.320	100/151	29.349		42.709	100/40	44.500		31.652	100/47
② Wt. Dish + Dry Sed.		20.720		24.410		22.332		26.321		29.352		42.714		44.500		31.655	
③ Wt. of Dish		12.054		11.980		12.259		12.114		11.998		12.217		11.990		11.877	
④ Wt. of Water, ① − ②		14.398		16.093		15.578		21.509		8.278		14.157		13.720		9.350	
⑤ Wt. of Dry Sed. ② − ③		8.668		12.430		10.073		14.207		17.354		30.497		32.510		19.778	
⑥ Water Content, ④/⑤		166.0		129.5		155.0		151.2		47.7		40.4		42.2		47.3	

TABLE W

Project: Water Content Study						Sediment: Seal Beach #1 & 2						Date: 4/9/69					
Drying Temperature: 160 °C						Sample No.: 4 & 4						Time: 1130					
Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →			W.C.														
Weigh. No.	Time (Hrs)	54.295	N.W.	36.411		41.527		48.888		35.292		61.117		49.623		46.683	
1	1230 (1.0)	40.910		25.960		29.470	88 79	36.150	73 67	23.910	93 103	46.880		35.640	71 79	33.030	
2	1330 (2.0)	33.880		24.030		27.670	98 88	31.340	99 91	23.078	100 110	37.850		29.940	99 110	28.500	
3	1430 (3.0)	33.500		24.016		27.636	100 90	31.228	100 92	23.073	100 110	35.308		29.784	99+ 111	28.374	
4	1530 (4.0)	33.500		24.016		27.635	100 90	31.229	100 92	23.069	100 110	35.274		29.774	100 111	28.359	
5	1630 (5.0)	33.499		24.015		27.635	100 90	31.228	100 92	23.064	100 110	35.271		29.770	100 111	28.359	
② Wt. Dish + Dry Sed.		33.500		24.016		27.636		31.228		23.064		35.274		29.774		28.359	
③ Wt. of Dish		12.060		11.987		12.265		12.121		11.998		12.223		11.996		11.884	
④ Wt. of Water, ① − ②		20.795		12.395		13.891		17.660		12.228		24.843		19.849		18.324	
⑤ Wt. of Dry Sed, ② − ③		21.440		12.029		15.371		19.107		11.066		23.051		17.778		17.475	
⑥ Water Content, ④/⑤		97.0		103.2		89.8		92.3		110.6		112.1		111.7		105.0	

TABLE X

Project: Water Content Study — Sediment: Elkhorn #1 & 2 — Date: 5/2/69

Drying Temperature: 160° C — Sample No.: 5 & 5 — Time: 1110

Dish Number		1		2		3		4		5		6		7		8	
1 Wt. Dish + Wet Sed. →		49.017	W.C. / N.W.	40.580		41.209		54.806		47.814		32.599		45.463		47.619	
Weigh. No.	Time (Hrs)																
1	1210 (1.0)	35.820	94 / 57	29.810	99+ / 61	29.240		42.150		33.330	70 / 97	20.610		31.520	74 / 96	34.580	
2	1310 (2.0)	35.065	99+ / 61	29.792	100 / 61	29.175		39.720		27.050	99+ / 139	20.380		26.560	99+ / 130	28.040	
3	1410 (3.0)	35.061	100 / 61	29.790	100 / 61	29.173		39.716		26.985	100 / 139	20.377		26.547	100 / 130	27.864	
4	1510 (4.0)	35.060	100 / 61	29.789	100 / 61	29.172		39.713		26.983	100 / 139	20.377		26.545	100 / 130	27.862	
5	1610 (5.0)	35.056	100 / 61	29.785	100 / 61	29.170		39.711		26.978	100 / 139	20.374		26.540	100 / 130	27.856	
2 Wt. Dish + Dry Sed.		35.060		29.789		29.172		39.713		26.983		20.377		26.545		27.862	
3 Wt. of Dish		12.055		11.982		12.260		12.115		11.993		12.218		11.991		11.879	
4 Wt. of Water, 1 − 2		13.961		10.795		12.039		15.095		20.836		12.225		18.923		19.763	
5 Wt. of Dry Sed, 2 − 3		23.005		17.807		16.912		27.598		14.990		8.159		14.554		15.987	
6 Water Content, 4/5		60.7		60.7		71.2		54.7		139.2		150.0		130.1		123.6	

TABLE Y

Project: Water Content Study

Sediment: Monterey Canyon & Buoy B

Date: 7/21/69

Drying Temperature: 160° C

Sample No.: 6 & 6

Time: 0825

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		32.117	W.C. N.W.	41.285		35.101		63.918		51.461		40.254		36.635		48.668	
Weigh. No.	Time (Hrs)																
1	0925 (1.0)	20.420		26.940	79 129	22.770		51.840	40 55	40.115	98 41	31.615	99+ 45	28.920		37.645	
2	1025 (2.0)	19.670		23.130	100 163	22.005		40.430	79 107	39.876	100 42	31.605	100 45	28.911		37.066	
3	1125 (3.0)	19.668		23.124	100 163	22.002		34.595	99 134	39.875	100 42	31.605	100 45	28.912		37.064	
4	1225 (4.0)	19.666		23.121	100 163	22.000		34.120	99+ 135	39.874	100 42	31.604	100 45	28.911		37.062	
5	0825 (24.0)	19.653		23.099	100 163	21.982		34.072	100 136	39.862	100 42	31.596	100 45	28.905		37.050	
② Wt. Dish + Dry Sed.		19.668		23.124		22.002		34.087		39.876		31.605		28.911		37.064	
③ Wt. of Dish		12.053		11.980		12.259		12.113		11.990		12.215		11.989		11.876	
④ Wt. of Water, ①−②		12.449		18.161		13.099		29.831		11.585		8.649		7.724		11.604	
⑤ Wt. of Dry Sed, ②−③		7.615		11.144		7.743		21.974		27.886		19.390		6.922		25.188	
⑥ Water Content, ④/⑤		163.7		163.0		169.5		136.0		41.6		44.6		45.6		46.1	

TABLE Z

Project: Water Content Study Sediment: Seal Beach #1 & 2 Date: 4/18/69

Drying Temperature: 170° C Sample No.: 7 & 7 Time: 1140

Dish Number		1		2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		52.174	W.C. N.W.	48.867		45.281		55.773		60.837		42.924		45.406		52.447	
Weigh. No.	Time (Hrs)																
1	1240 (1.0)	36.980		33.510	85 82	30.050	91 93	40.660		46.580		28.900	91 93	32.130		36.630	78 78
2	1340 (2.0)	33.620		30.680	99+ 97	28.600	100 102	34.950		37.110		27.380	100 102	28.630		32.170	99+ 99+
3	1440 (3.0)	33.587		30.676	100 97	28.595	100 102	34.889		34.515		27.378	100 102	28.614		32.139	100 100
4	1540 (4.0)	33.581		30.674	100 97	28.584	100 102	34.872		34.490		27.376	100 102	28.614		32.138	100 100
5	1640 (5.0)	33.578		30.670	100 97	28.581	100 102	34.869		34.475		27.376	100 102	28.612		32.138	100 100

	1	2	3	4	5	6	7	8
② Wt. Dish + Dry Sed.	33.578	30.670	28.584	34.869	34.475	27.376	28.614	32.138
③ Wt. of Dish	12.058	11.986	12.264	12.120	11.997	12.222	11.995	11.883
④ Wt. of Water, ①−②	18.596	18.197	16.697	20.900	26.382	15.548	16.792	20.309
⑤ Wt. of Dry Sed, ②−③	21.520	18.684	16.320	22.749	22.478	15.154	16.619	20.255
⑥ Water Content, ④/⑤	86.5	97.5	102.3	92.1	117.1	102.7	101.0	100.1

TABLE Za

Project: Water Content Study | Sediment: Elkhorn #1 & 2 | Date: 4/23/69

Drying Temperature: 170° C | Sample No.: 2 & 2 | Time: 1215

Dish Number		1		2		3		4		5		6		7		8	
①Wt. Dish+Wet Sed. →		33.313	W.C. N.W.	48.517		44.614		45.434		53.525		39.206		28.836		37.725	
Weigh. No.	Time (Hrs)																
1	1315 (1.0)	24.410		35.490	90 59	31.330	99 70	31.970		37.280	70 90	25.000	90 127	18.800		22.990	
2	1415 (2.0)	24.410		34.070	99+ 66	31.260	100 70	31.530		30.230	99+ 128	23.436	100 141	18.784		22.070	
3	1515 (3.0)	24.403		34.058	99+ 66	31.252	100 70	31.517		30.159	100 129	23.430	100 141	18.771		22.065	
4	1615 (4.0)	24.402		34.053	100 66	31.247	100 70	31.516		30.156	100 129	23.427	100 141	18.790		22.060	
5	1715 (5.0)	24.401		34.051	100 66	31.247	100 70	31.514		30.151	100 129	23.428	100 141	18.789		22.057	
②Wt. Dish + Dry Sed.		24.402		34.051		31.247		31.516		30.156		23.427		18.790		22.060	
③Wt. of Dish		12.056		11.984		12.262		12.118		11.995		12.220		11.993		11.881	
④Wt. of Water, ①−②		8.911		14.466		13.367		13.918		23.369		15.779		10.046		15.665	
⑤Wt. of Dry Sed, ②−③		12.346		22.067		18.985		19.398		18.161		11.207		6.799		10.179	
⑥Water Content, ④/⑤		72.2		65.5		70.3		71.8		128.5		141.0		147.7		154.2	

TABLE Zb

Project: Water Content Study

Drying Temperature: 170 °C

Sediment: Monterey Canyon & Buoy B

Sample No.: 7 & 7

Date: 7/22/69

Time: 0830

Dish Number		1	W.C. N.W.	2		3		4		5		6		7		8	
① Wt. Dish + Wet Sed. →		33.031		35.006		41.957		52.700		40.565		50.880		48.346		39.028	
Weigh. No.	Time (Hrs)																
1	0930 (1.0)	19.810		22.390		27.180	88 115	38.280	60 90	31.924	99+ 44	39.016	98 42	37.396		30.604	
2	1030 (2.0)	19.553		21.560		25.200	100 130	29.340	94 141	31.917	100 44	38.996	99+ 44	37.384		30.598	
3	1130 (3.0)	19.550		21.559		25.196	100 130	28.310	100 151	31.915	100 44	38.993	100 44	37.381		30.595	
4	1430 (6.0)	19.543		21.552		25.187	100 130	28.304	100 151	31.913	100 44	38.989	100 44	37.377		30.593	
② Wt. Dish + Dry Sed.		19.550		21.559		25.196		28.304		31.915		38.993		37.381		30.595	
③ Wt. of Dish		12.052		11.979		12.258		12.113		11.991		12.26		11.988		11.877	
④ Wt. of Water, ①−②		13.481		13.447		16.761		24.396		8.652		11.891		10.965		8.433	
⑤ Wt. of Dry Sed, ②−③		7.498		9.580		12.938		16.191		19.924		26.777		25.393		18.718	
⑥ Water Content, ④/⑤		179.8		140.5		129.5		150.8		43.5		44.5		43.2		45.0	

Corrections Applied to Certain Data Sheets

1. Monterey Canyon & Buoy B, Drying Temperature = 90°C: Scale out of balance by - 0.003g on weighing number 6.

   Sub-sample dish number 4 contained granidorite pebbles -- sample rerun as shown in Table D.

2. Monterey Canyon & Buoy B, Drying Temperature = 120°C: Scale out of balance by + 0.002g on weighing number 4.

3. Monterey Canyon & Buoy B, Drying Temperature = 130°C: Scale out of balance by + 0.002g on weighing number 7.

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13. ABSTRACT

The question pertaining to the acceptance of a standard drying temperature of 110 $\pm$ 5°C in making water content determinations of soils has been extended to the oven drying of marine sediments. The implementation of a temperature within the 130 to 150°C range appears to be just as adequate as the accepted standard for the drying of inorganic sediments and has the added advantage of shortening the drying time. Increasing the temperature above 150°C does not appreciably reduce the drying time and may begin to break down the less stable clay sediments such as montmorillonite. The water content determinations appear to fluctuate in a random manner with increase in drying temperature suggesting that the mineralogy of the sediments somehow controls water content. The concept of normalized water content is introduced and appears to be an invaluable aid in considering the relationships between water content, sample weight and drying time.

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
The Drying of Marine Sediments for Water Content Determinations.						
Temperatures above $150^{\circ}C$ break down clay sediments.						
Normalized water content introduced.						
Role that soluble salts play in controlling water content discussed.						

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